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**Tang et al.**

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(54) **OPTICAL IMAGE CAPTURING SYSTEM**  
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This patent is subject to a terminal disclaimer.

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**G02B 9/60** (2006.01)  
**G02B 13/00** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **G02B 13/0045** (2013.01); **G02B 9/60** (2013.01)

(58) **Field of Classification Search**  
CPC ..... G02B 9/60; G02B 13/0045  
USPC ..... 359/707, 714, 754, 763-769  
See application file for complete search history.

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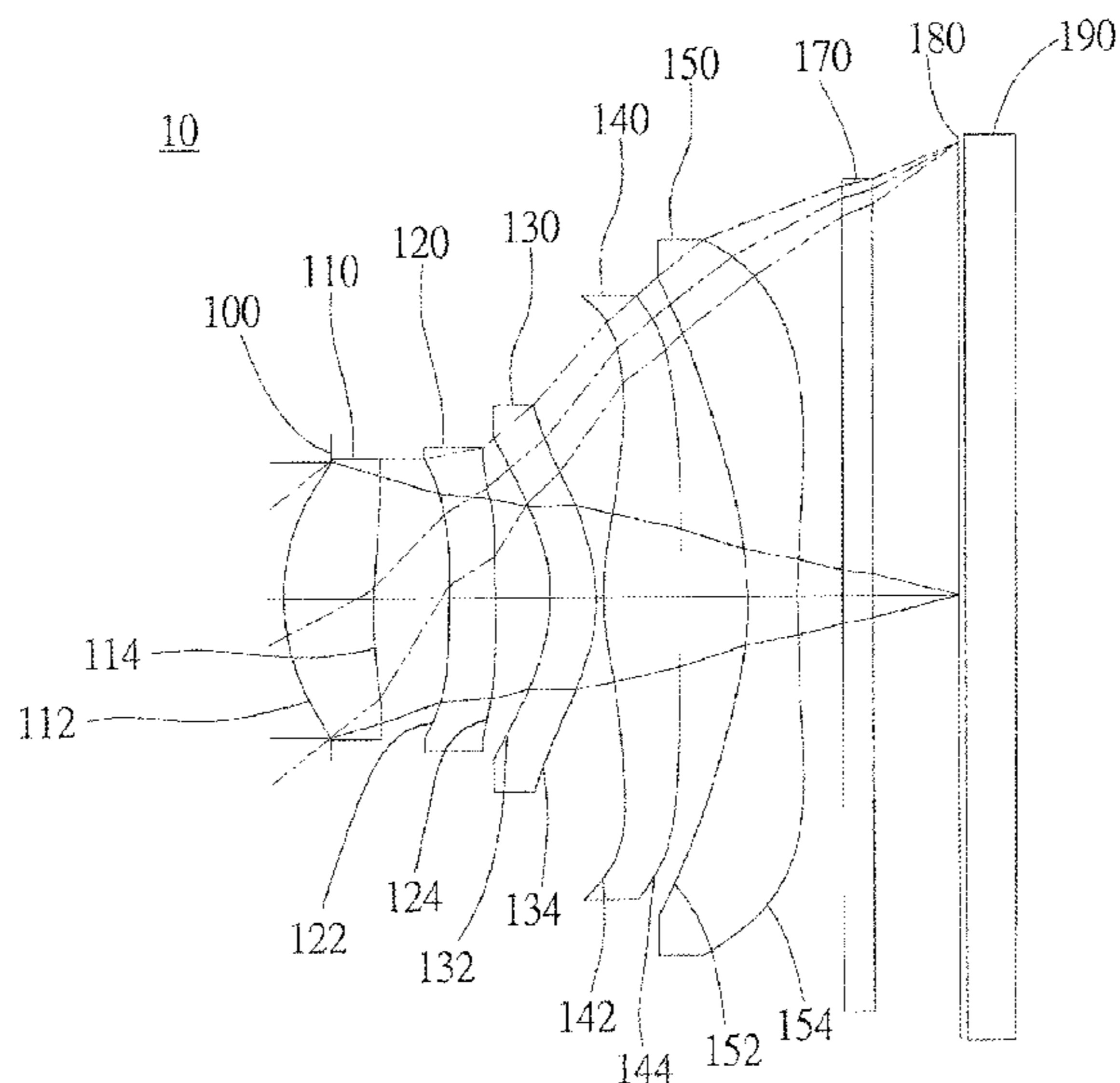
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(57) **ABSTRACT**  
A five-piece optical lens for capturing image and a five-piece optical module for capturing image, along the optical axis in order from an object side to an image side, include a first lens with refractive power having an object-side surface which can be convex; a second lens with refractive power; a third lens with refractive power; a fourth lens with negative refractive power; and a fifth lens which can have negative refractive power, wherein an image-side surface thereof can be concave, and at least one surface of the fifth lens has an inflection point; both surfaces of each of the five lenses are aspheric. The optical lens can increase aperture value and improve the imaging quality for use in compact cameras.

**22 Claims, 12 Drawing Sheets**



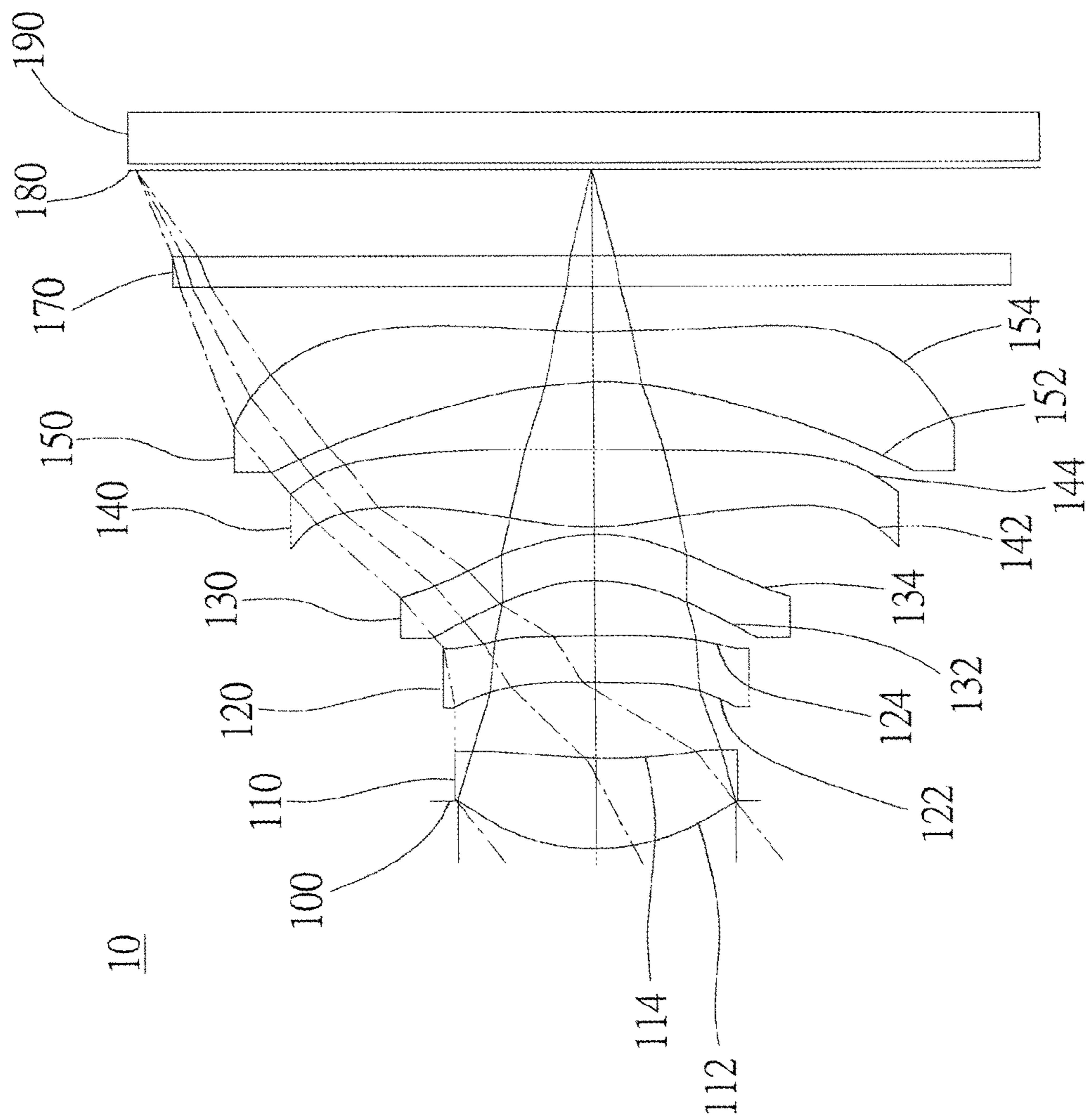


FIG. 1 A

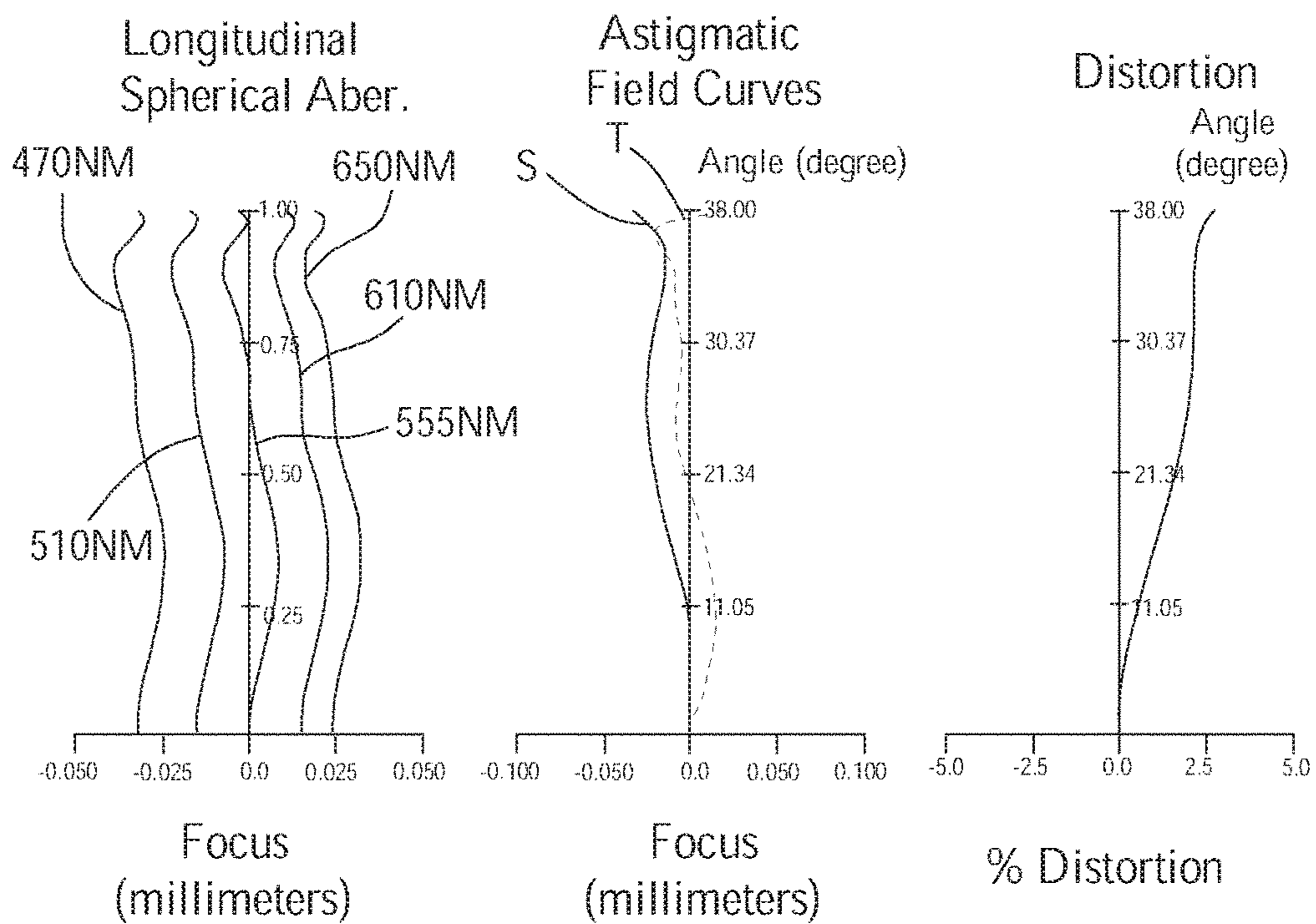


FIG. 1 B

—— Parax FOV  
- - - Actual FOV

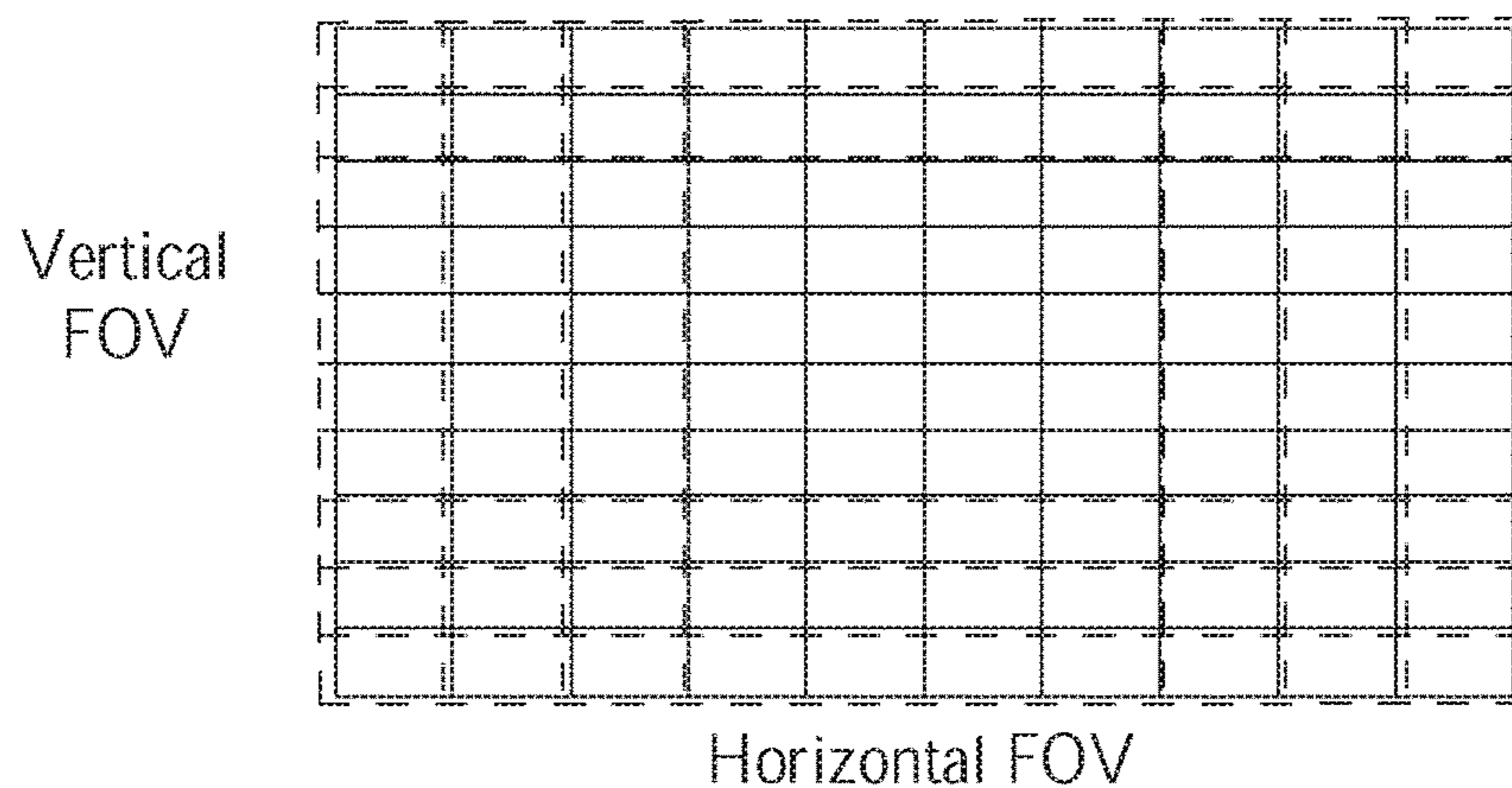


FIG. 1 C

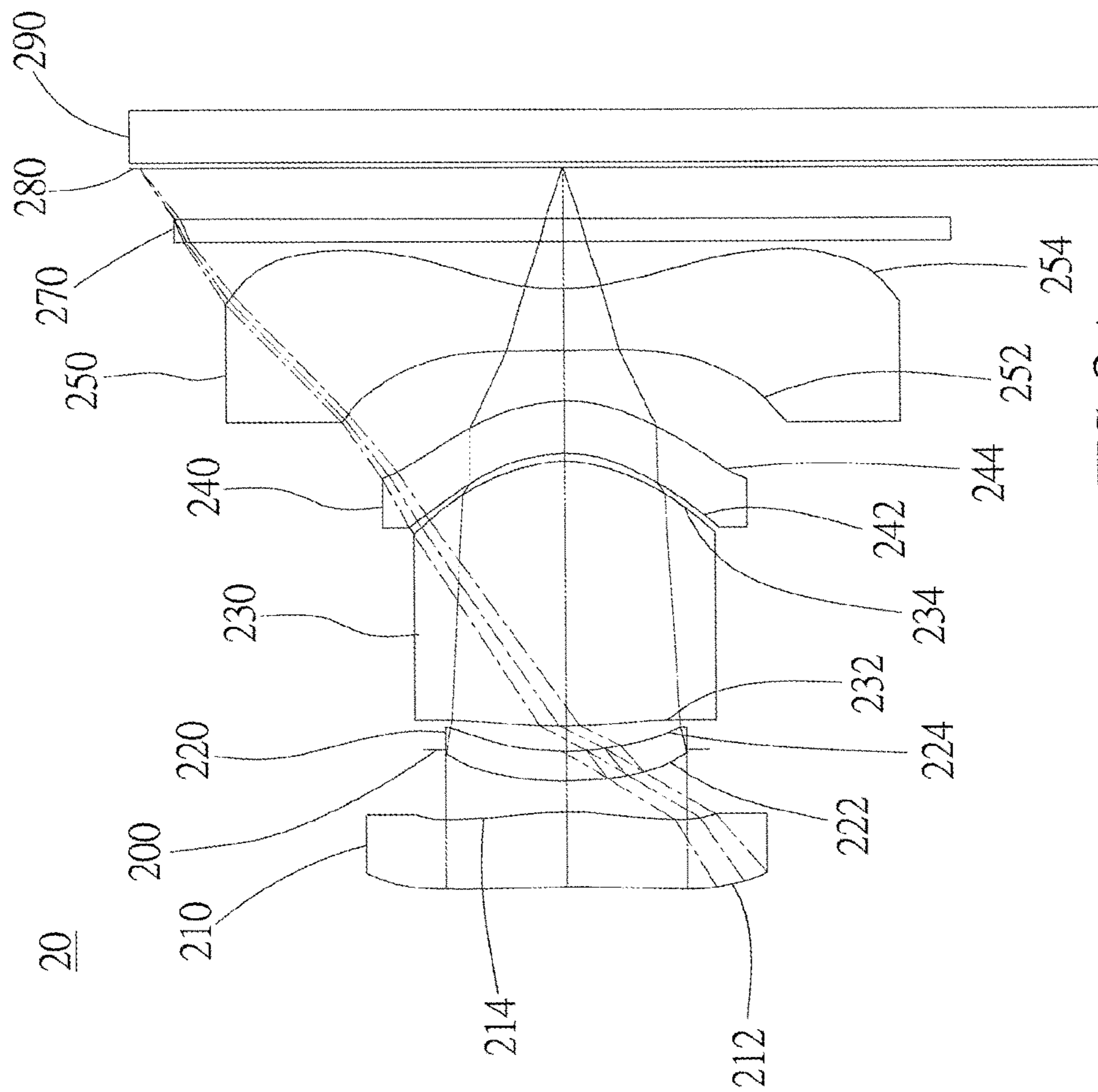


FIG. 2 A

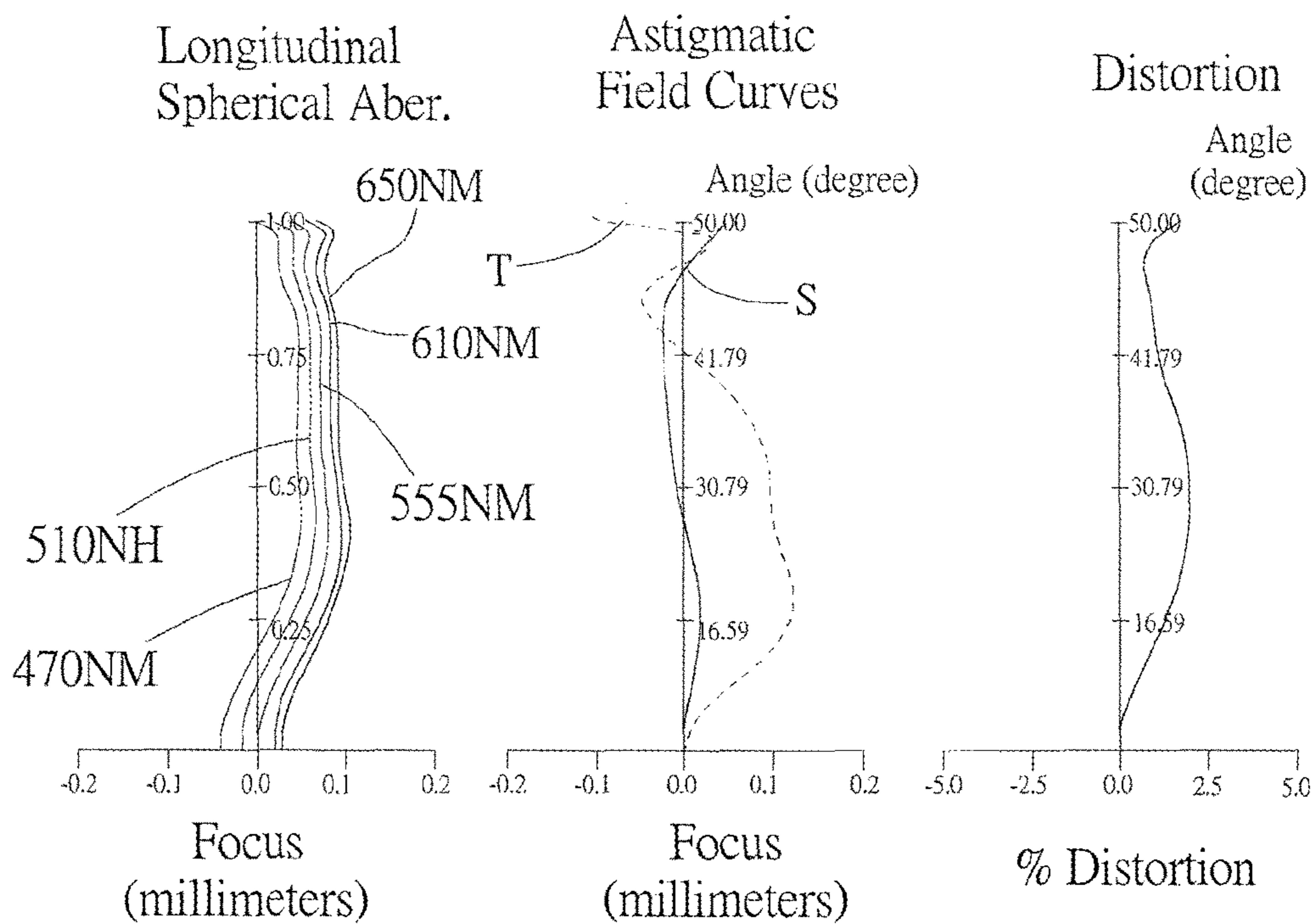


FIG. 2 B

—— Parax FOV  
 - - - Actual FOV

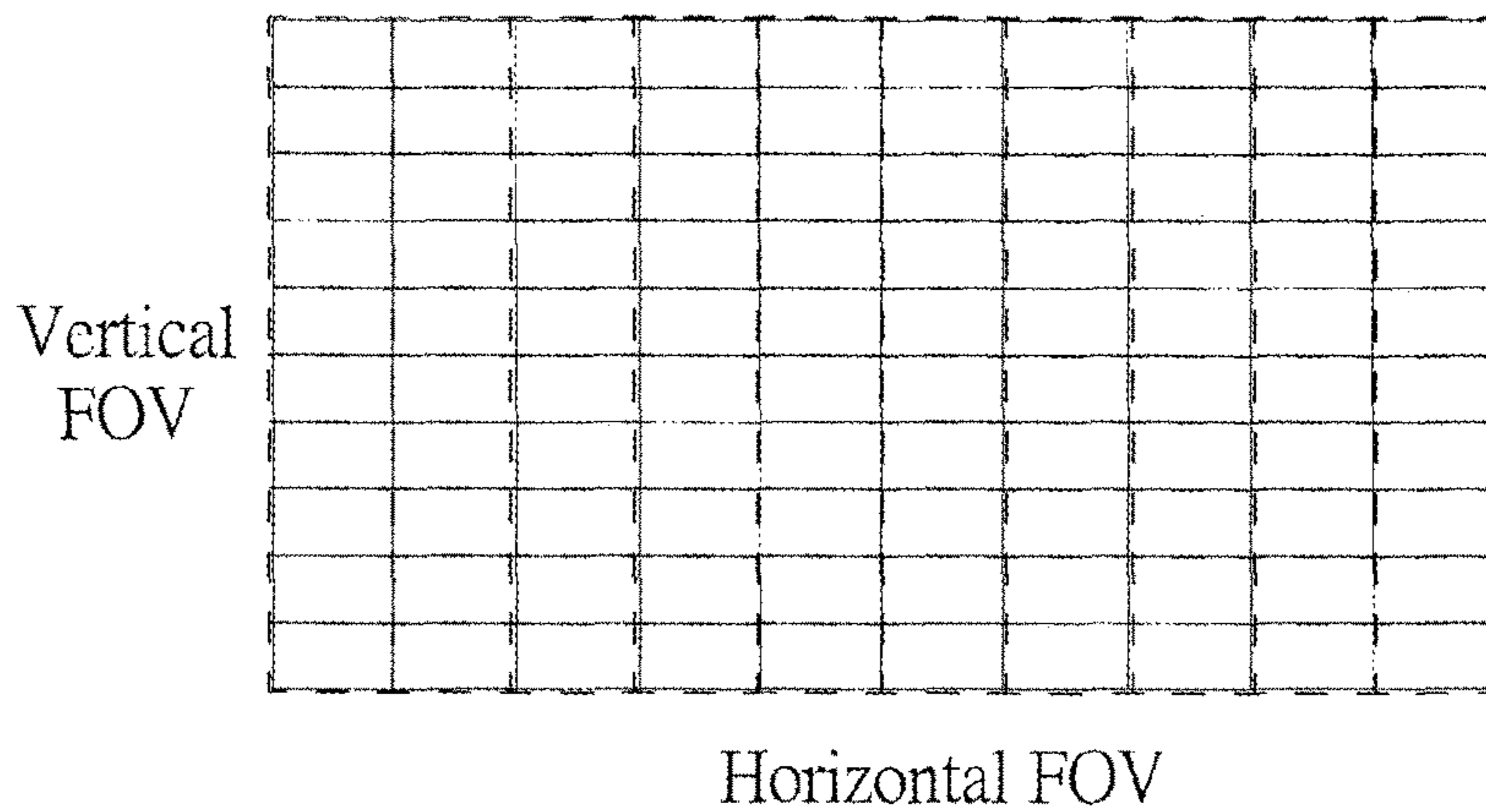


FIG. 2 C

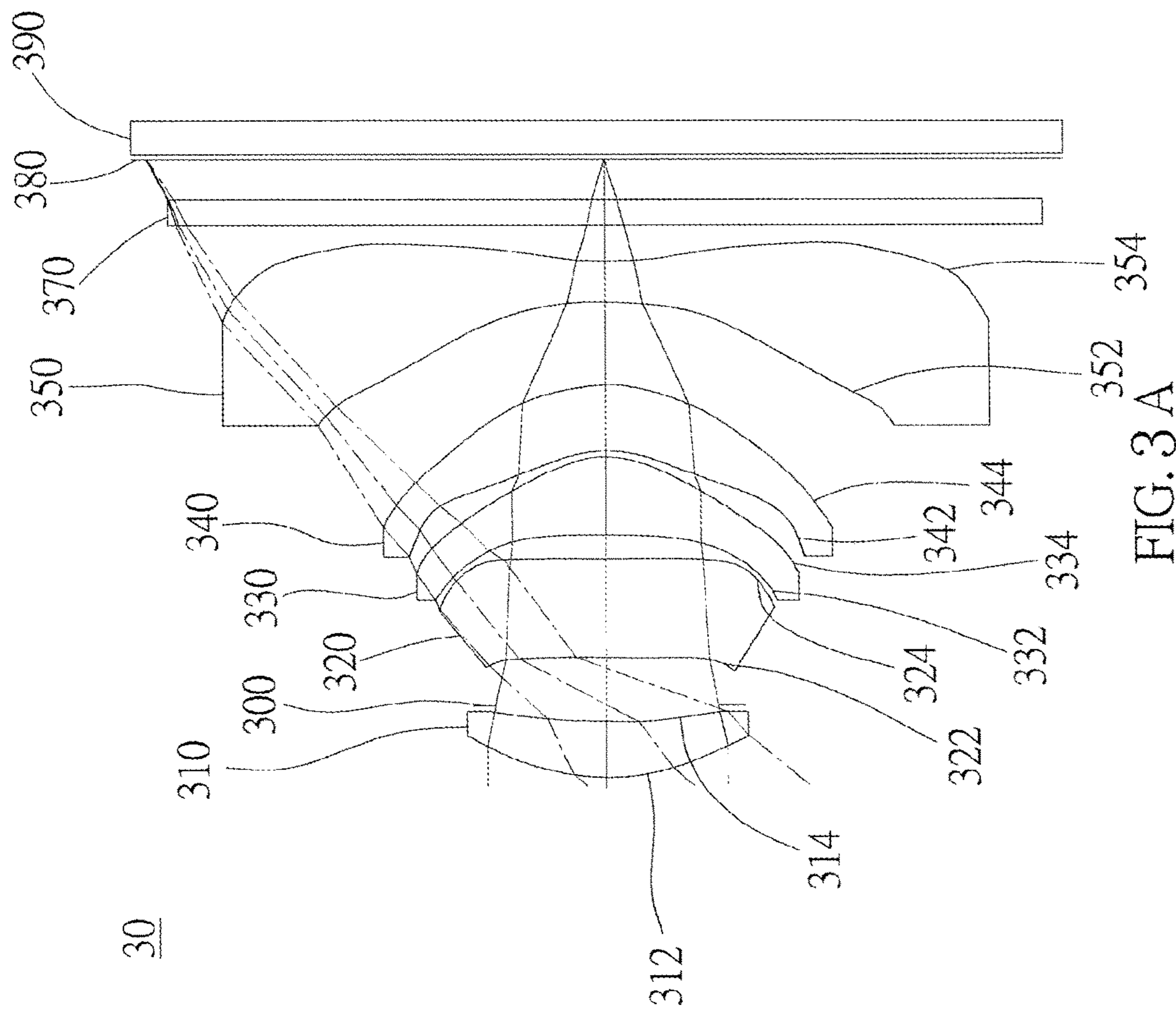


FIG. 3 A

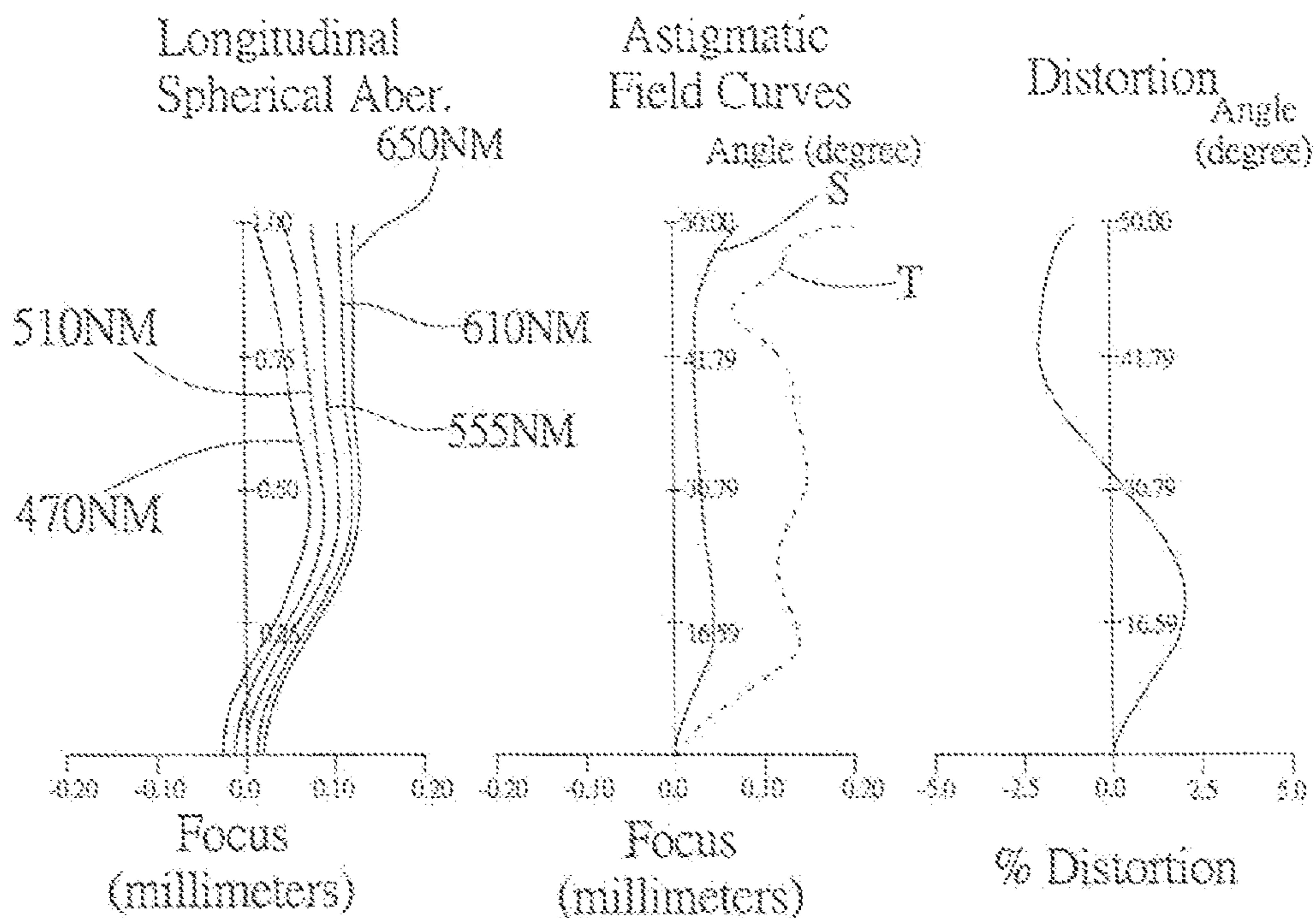


FIG. 3 B

----- Parax FOV  
- - - - Actual FOV

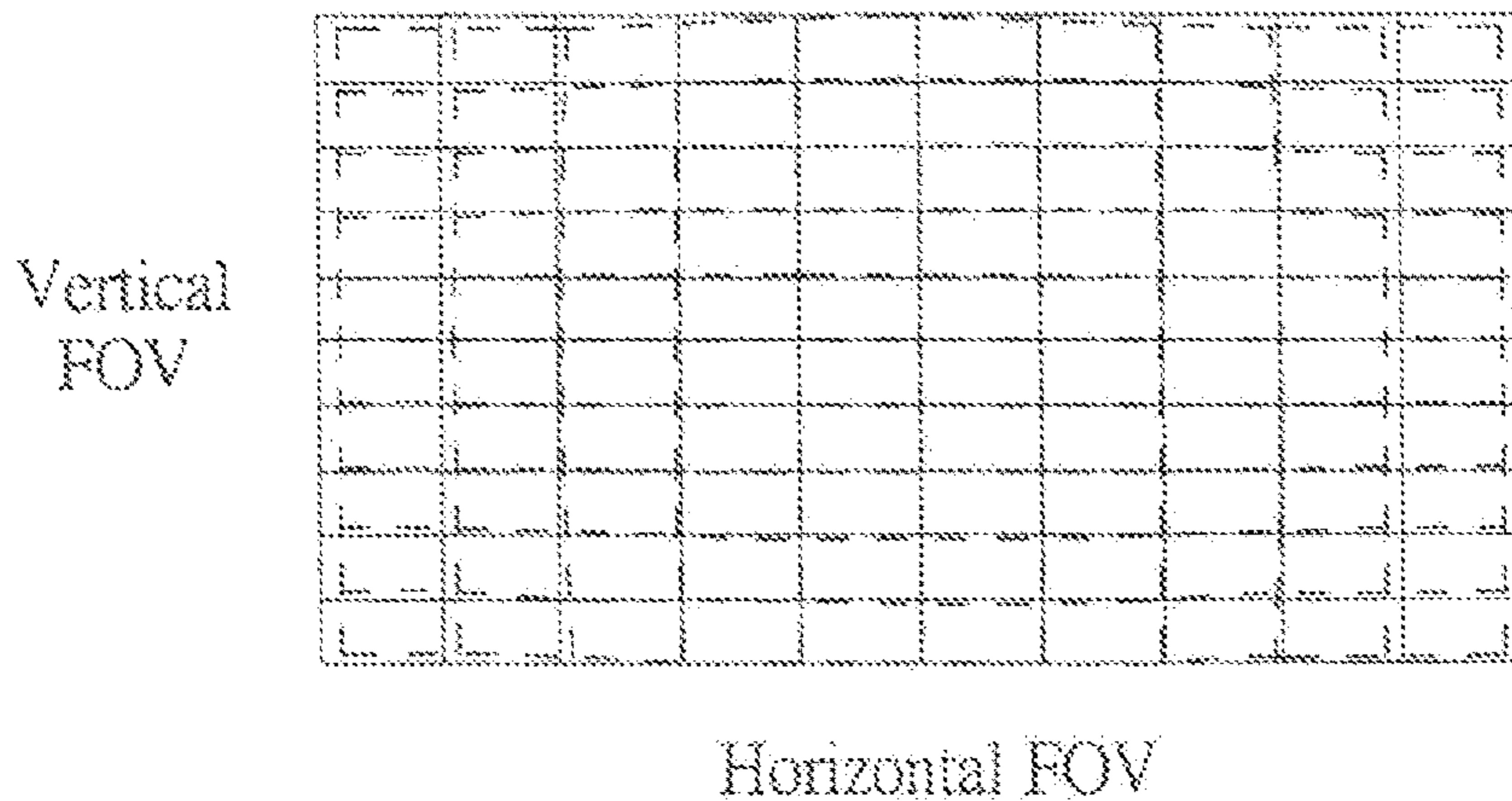


FIG. 3 C

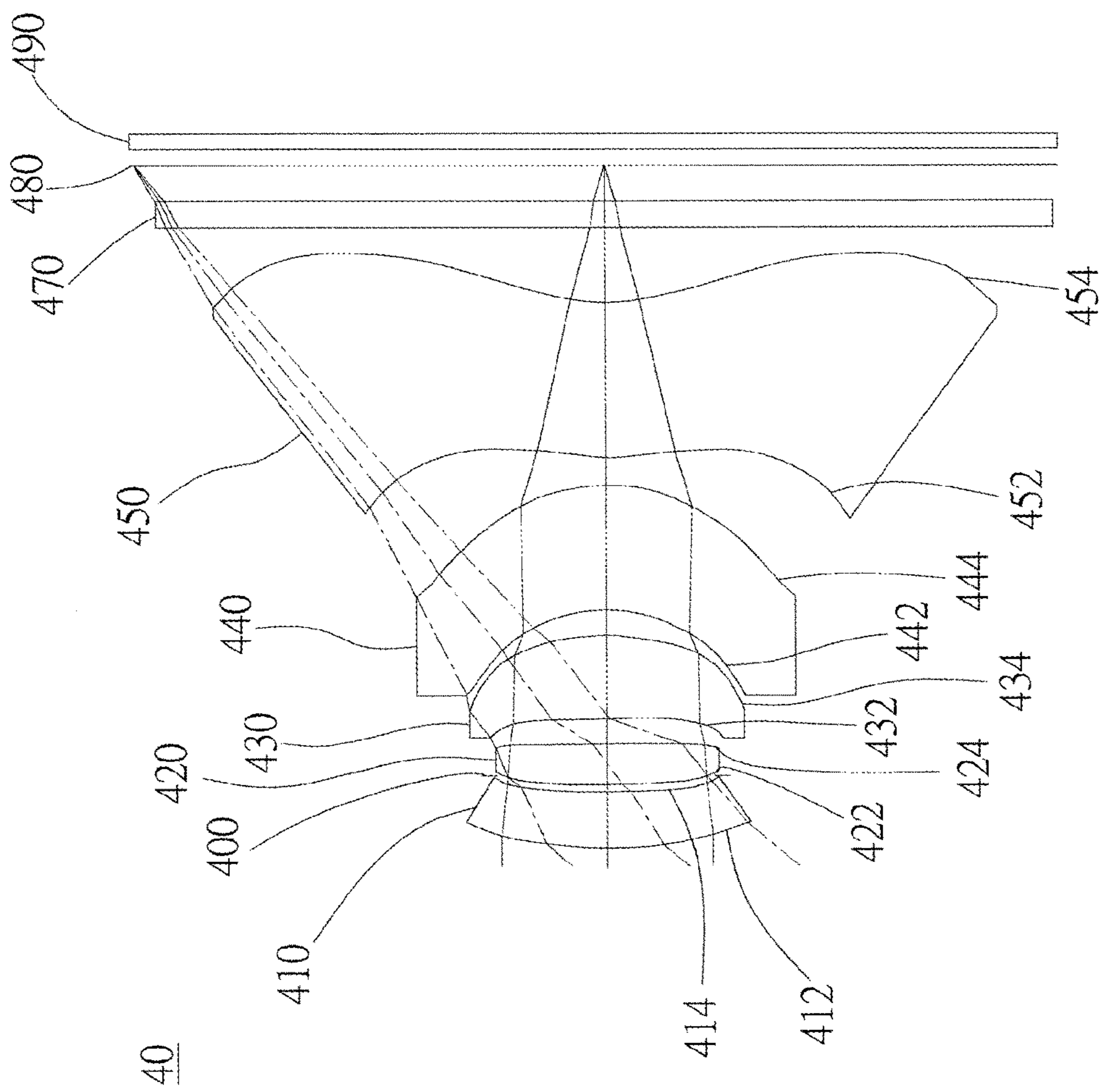


FIG. 4 A



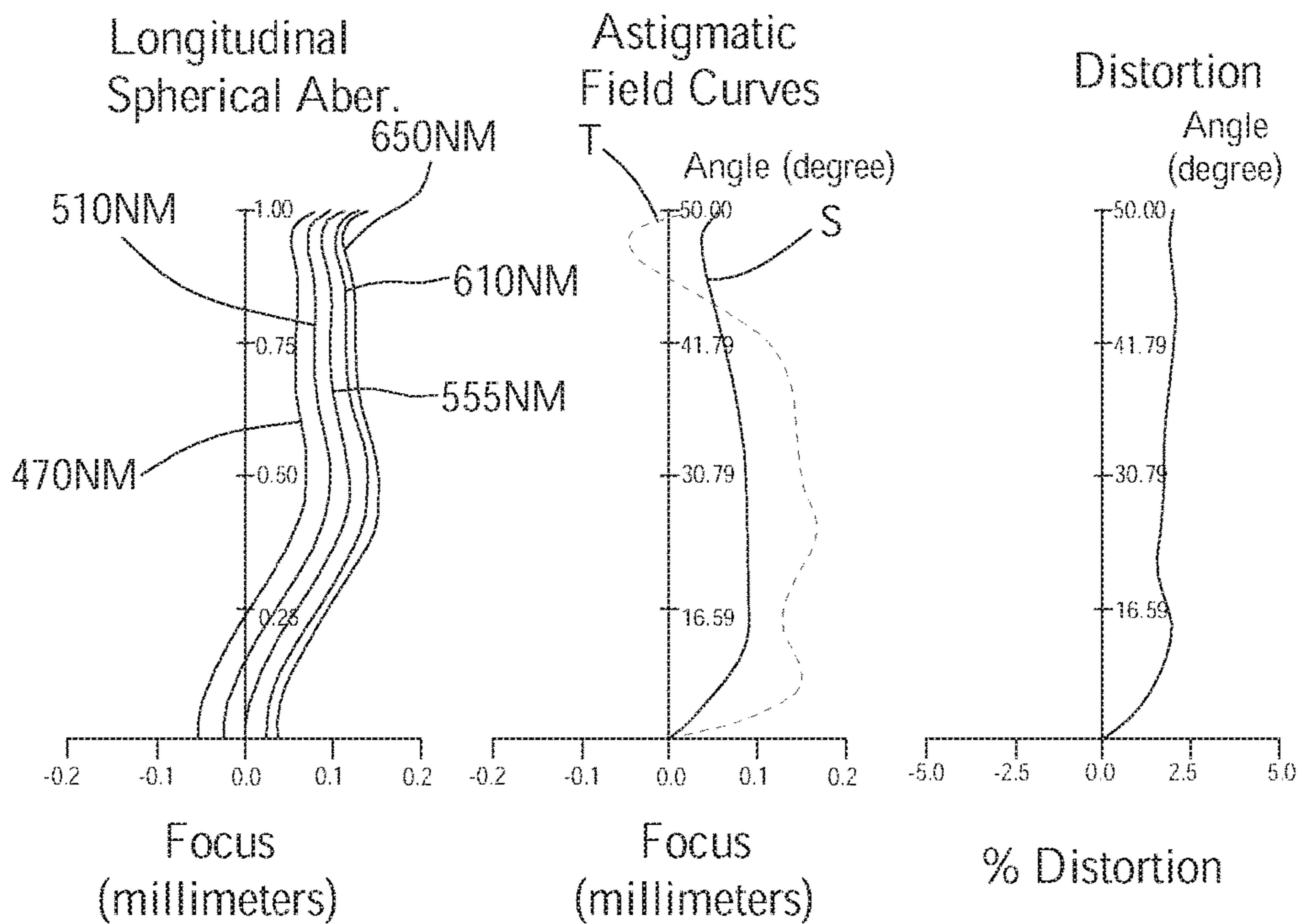
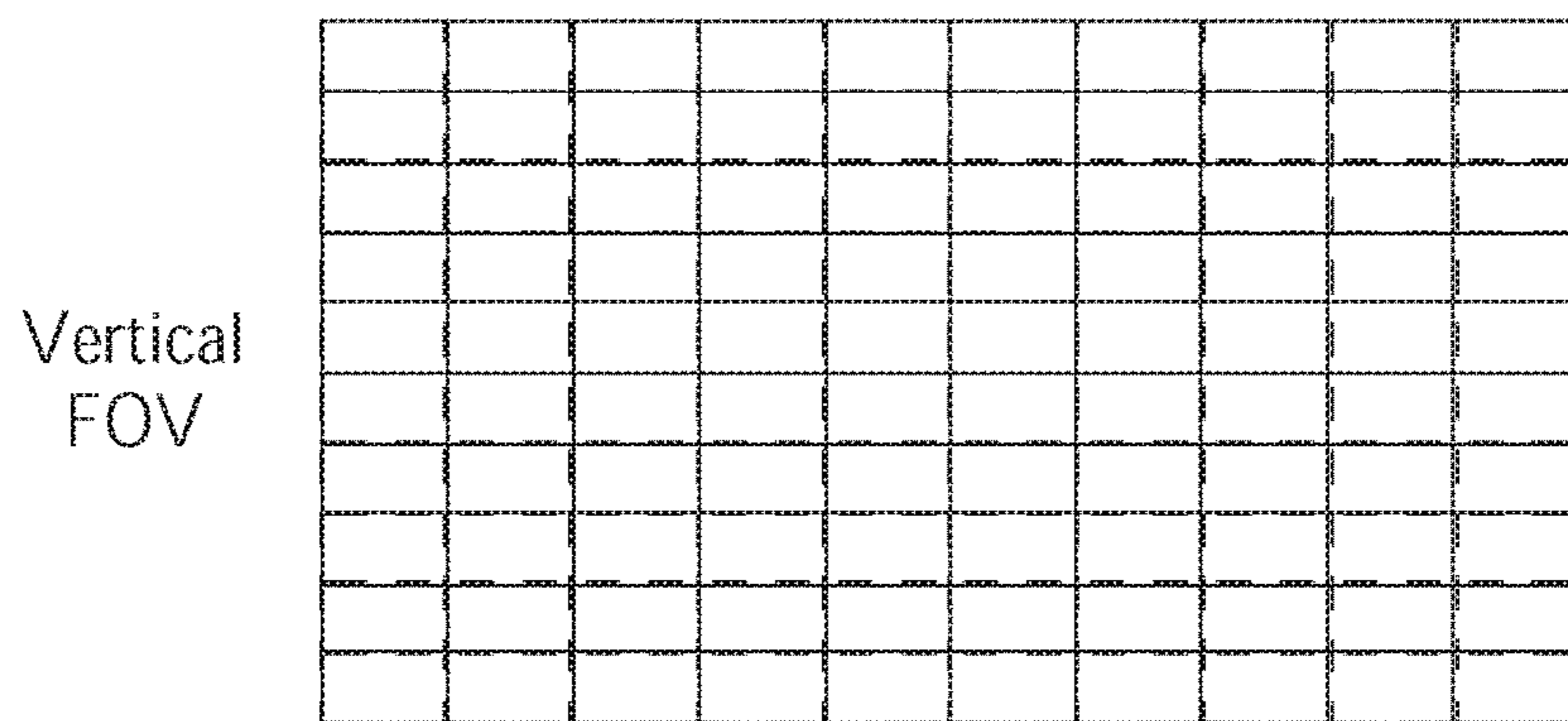


FIG. 4 B

— Parax FOV  
- - - Actual FOV



Horizontal FOV

FIG. 4 C

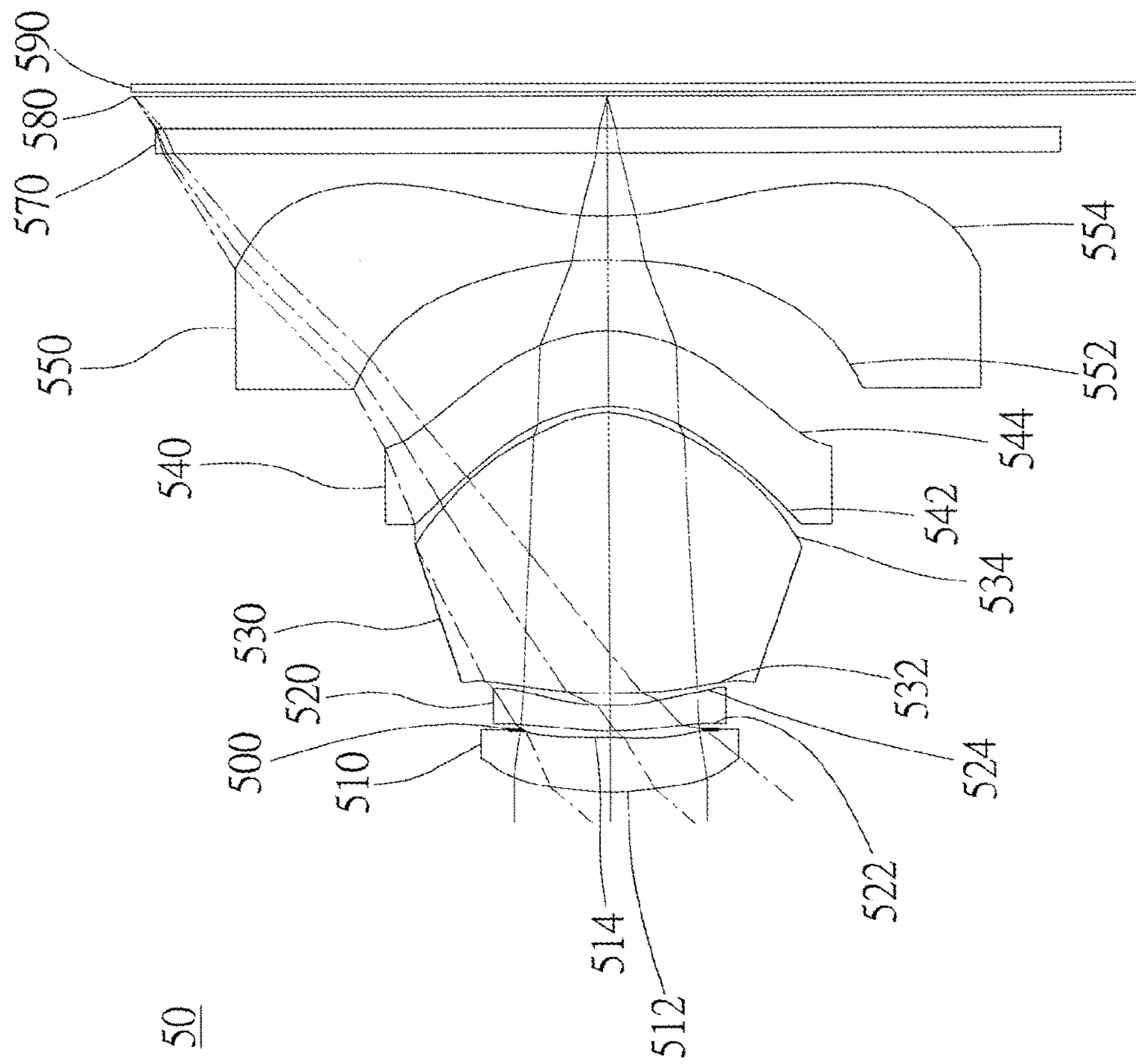


FIG. 5 A

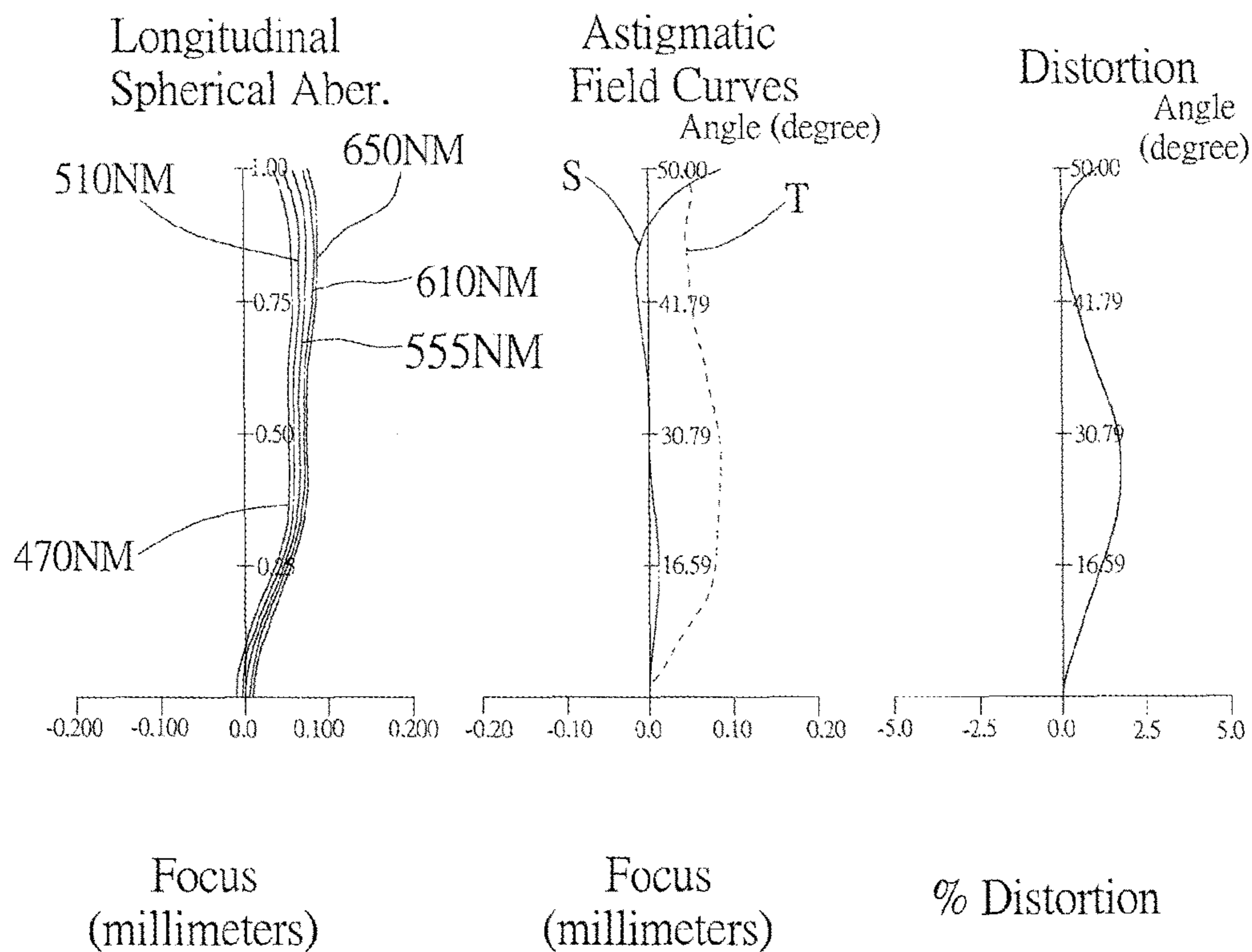


FIG. 5 B

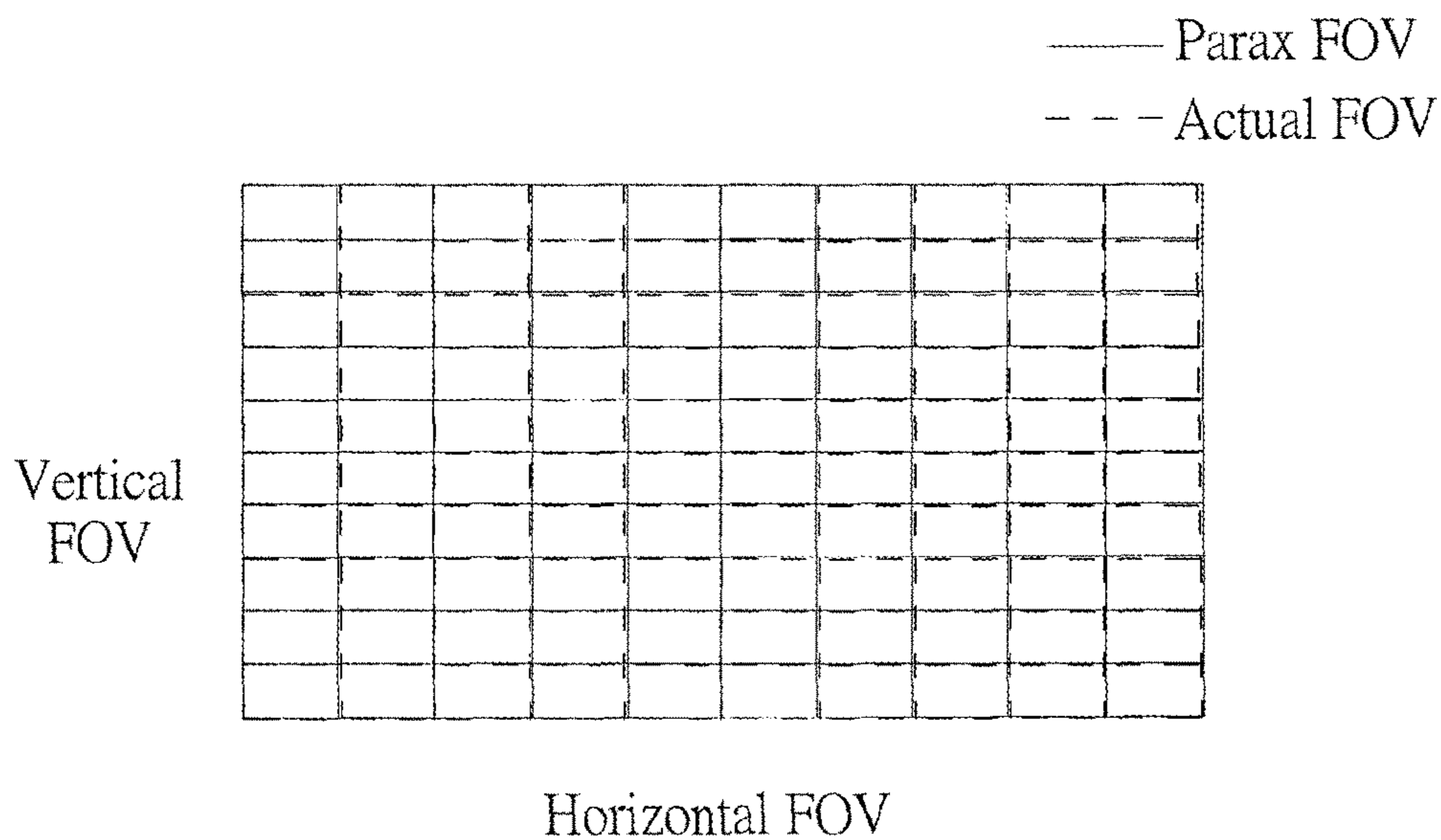


FIG. 5 C

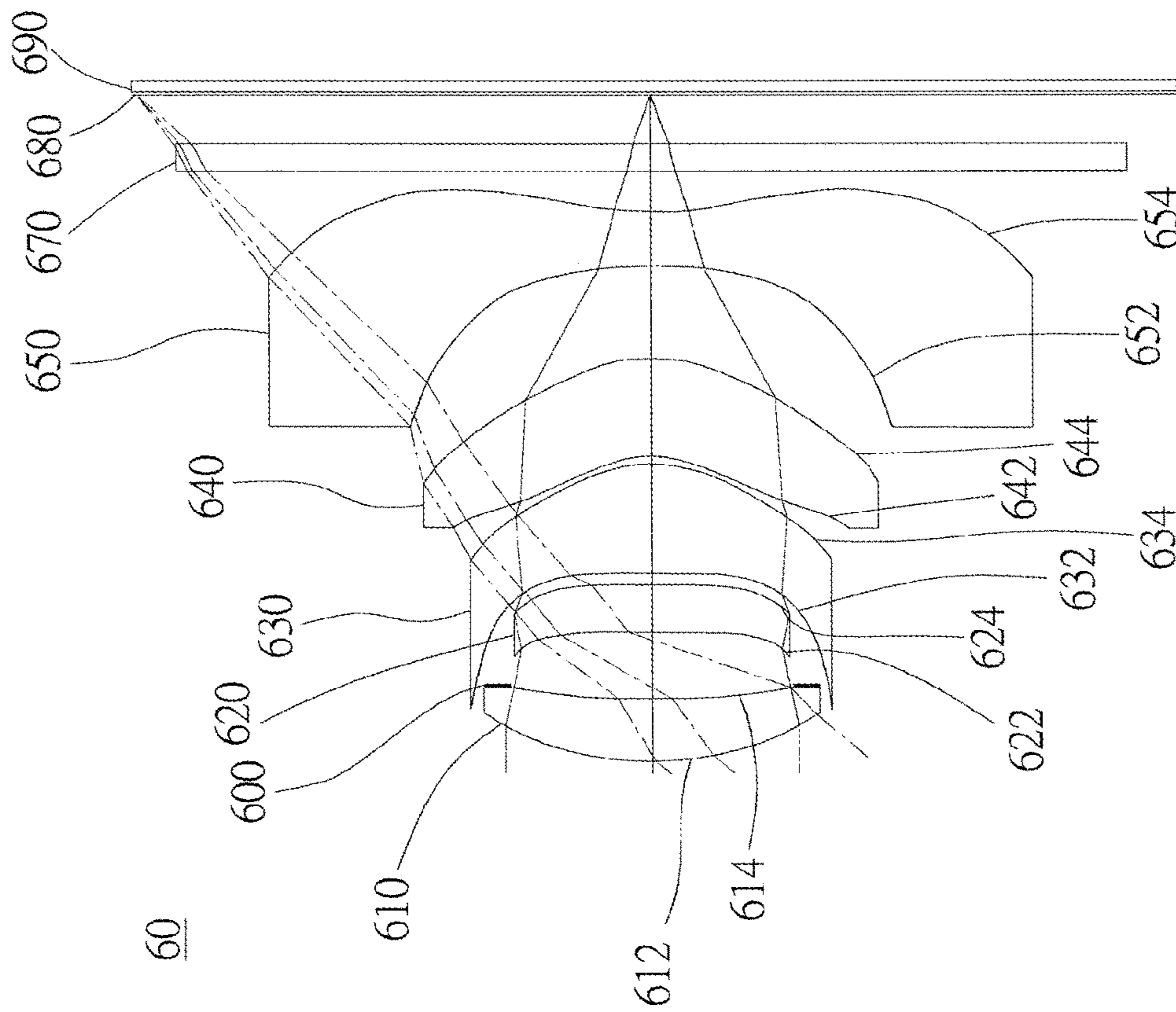


FIG. 6 A

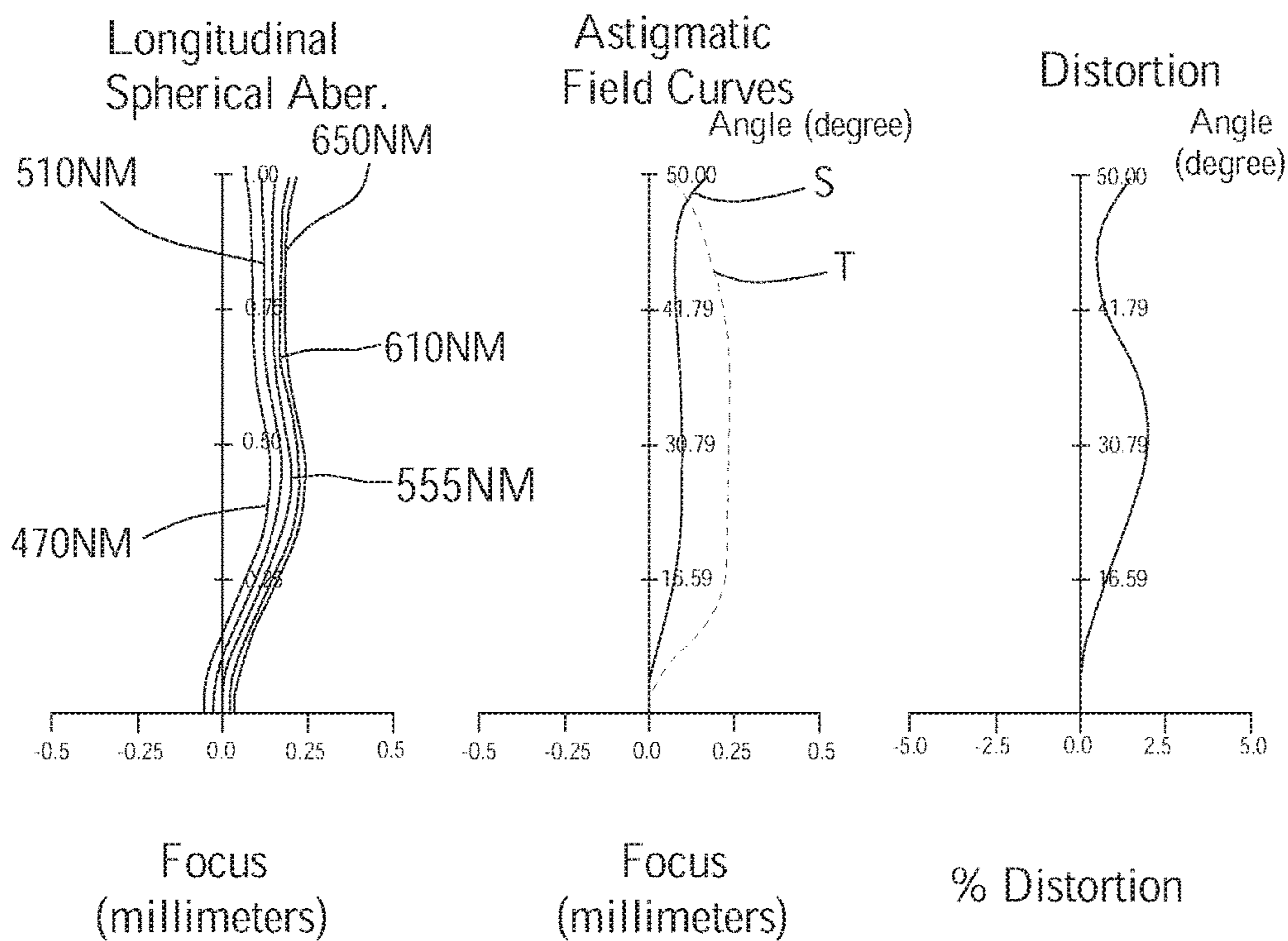


FIG. 6 B

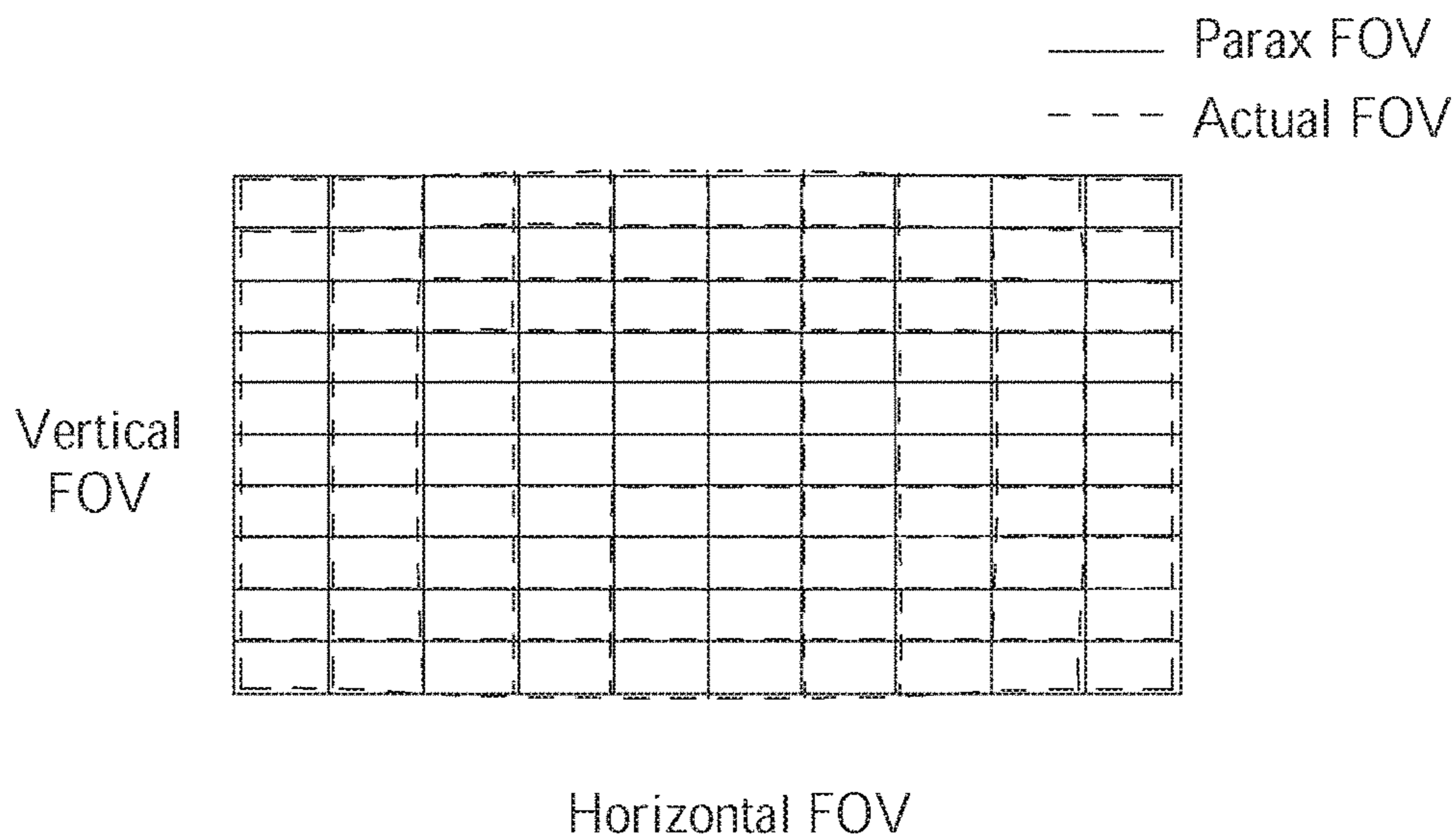


FIG. 6 C



to adjust the incident angle of each view field and modify the ODT and the TDT. In addition, the surfaces of the fifth lens are capable of modifying the optical path to improve the imaging quality.

The optical image capturing system of the present invention includes a first lens, a second lens, a third lens, a fourth lens, and a fifth lens in order along an optical axis from an object side to an image side. The first lens has positive refractive power, and the fifth lens has refractive power. Both the object-side surface and the image-side surface of the fifth lens are aspheric surfaces. The optical image capturing system satisfies:

$$1.2 \leq f/HEP \leq 2.8 \text{ and } 0.5 \leq HOS/f \leq 3.0;$$

where  $f$  is a focal length of the optical image capturing system; HEP is an entrance pupil diameter of the optical image capturing system; and HOS is a distance in parallel with the optical axis between an object-side surface, which face the object side, of the first lens and the image plane.

The present invention further provides an optical image capturing system, including a first lens, a second lens, a third lens, a fourth lens, and a fifth lens in order along an optical axis from an object side to an image side. The first lens has positive refractive power, and both the object-side surface and the image-side surface thereof are aspheric surfaces. The second lens has negative refractive power, and the third and the fourth lenses have refractive power. The fifth lens has refractive power, and both an object-side surface and an image-side surface thereof are aspheric surfaces. The optical image capturing system satisfies:

$$1.2 \leq f/HEP \leq 2.8; 0.5 \leq HOS/f \leq 3.0; 0.4 \leq |\tan(HAF)| \leq 3.0; |TDT| < 60\%; \text{ and } |ODT| \leq 50\%;$$

where  $f$  is a focal length of the optical image capturing system; HEP is an entrance pupil diameter of the optical image capturing system; HOS is a distance in parallel with the optical axis between an object-side surface, which face the object side, of the first lens and the image plane; HAF is a half of the view angle of the optical image capturing system; TDT is a TV distortion; and ODT is an optical distortion.

The present invention further provides an optical image capturing system, including a first lens, a second lens, a third lens, a fourth lens, and a fifth lens in order along an optical axis from an object side to an image side. At least two of these five lenses have at least an inflection point on a side thereof respectively. The first lens has positive refractive power, and both an object-side surface and an image-side surface thereof are aspheric surfaces. The second and the third lens have refractive power, and the fourth lens has negative refractive power. The fifth lens has negative refractive power, wherein an image-side surface thereof has at least an inflection point, and both an object-side surface and the image side surface thereof are aspheric surfaces. The optical image capturing system satisfies:

$$1.2 \leq f/HEP \leq 2.8; 0.5 \leq HOS/f \leq 3.0; 0.4 \leq |\tan(HAF)| \leq 3.0; |TDT| < 60\%; \text{ and } |ODT| \leq 50\%;$$

where  $f$  is a focal length of the optical image capturing system; HEP is an entrance pupil diameter of the optical image capturing system; HOS is a distance in parallel with the optical axis between an object-side surface, which face the object side, of the first lens and the image plane; HAF is a half of the view angle of the optical image capturing system; TDT is a TV distortion; and ODT is an optical distortion.

In an embodiment, the optical image capturing system further includes an image sensor with a size less than 1/1.2"

in diagonal, and a pixel less than 1.4  $\mu\text{m}$ . A preferable size is 1/2.3", and a preferable pixel size of the image sensor is less than 1.12  $\mu\text{m}$ , and more preferable pixel size is less than 0.9  $\mu\text{m}$ . A 16:9 image sensor is available for the optical image capturing system of the present invention.

In an embodiment, the optical image capturing system of the present invention is available to high-quality (4K2K, so called UHD and QHD) recording, and provides high quality of image.

In an embodiment, a height of the optical image capturing system (HOS) can be reduced while  $|f1| > f5$ .

In an embodiment, when the lenses satisfy  $|f2| + |f3| + |f4| > |f1| + |f5|$ , at least one of the lenses from the second lens to the fourth lens could have weak positive refractive power or weak negative refractive power. The weak refractive power indicates that an absolute value of the focal length is greater than 10. When at least one of the lenses from the second lens to the fourth lens could have weak positive refractive power, it may share the positive refractive power of the first lens, and on the contrary, when at least one of the lenses from the second lens to the fourth lens could have weak negative refractive power, it may finely modify the aberration of the system.

In an embodiment, the fifth lens has negative refractive power, and an image-side surface thereof can be concave, it may reduce back focal length and size. Besides, the fifth lens has at least an inflection point on at least a surface thereof, which may reduce an incident angle of the light of an off-axis field of view and modify the aberration of the off-axis field of view.

#### BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The present invention will be best understood by referring to the following detailed description of some illustrative embodiments in conjunction with the accompanying drawings, in which

FIG. 1A is a schematic diagram of a first preferred embodiment of the present invention;

FIG. 1B shows curve diagrams of longitudinal spherical aberration, astigmatic field, and optical distortion of the optical image capturing system in the order from left to right of the first embodiment of the present application;

FIG. 1C shows a curve diagram of TV distortion of the optical image capturing system of the first embodiment of the present application;

FIG. 2A is a schematic diagram of a second preferred embodiment of the present invention;

FIG. 2B shows curve diagrams of longitudinal spherical aberration, astigmatic field, and optical distortion of the optical image capturing system in the order from left to right of the second embodiment of the present application;

FIG. 2C shows a curve diagram of TV distortion of the optical image capturing system of the second embodiment of the present application;

FIG. 3A is a schematic diagram of a third preferred embodiment of the present invention;

FIG. 3B shows curve diagrams of longitudinal spherical aberration, astigmatic field, and optical distortion of the optical image capturing system in the order from left to right of the third embodiment of the present application;

FIG. 3C shows a curve diagram of TV distortion of the optical image capturing system of the third embodiment of the present application;

FIG. 4A is a schematic diagram of a fourth preferred embodiment of the present invention;

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FIG. 4B shows curve diagrams of longitudinal spherical aberration, astigmatic field, and optical distortion of the optical image capturing system in the order from left to right of the fourth embodiment of the present application;

FIG. 4C shows a curve diagram of TV distortion of the optical image capturing system of the fourth embodiment of the present application;

FIG. 5A is a schematic diagram of a fifth preferred embodiment of the present invention;

FIG. 5B shows curve diagrams of longitudinal spherical aberration, astigmatic field, and optical distortion of the optical image capturing system in the order from left to right of the fifth embodiment of the present application;

FIG. 5C shows a curve diagram of TV distortion of the optical image capturing system of the fifth embodiment of the present application;

FIG. 6A is a schematic diagram of a sixth preferred embodiment of the present invention;

FIG. 6B shows curve diagrams of longitudinal spherical aberration, astigmatic field, and optical distortion of the optical image capturing system in the order from left to right of the sixth embodiment of the present application; and

FIG. 6C shows a curve diagram of TV distortion of the optical image capturing system of the sixth embodiment of the present application.

#### DETAILED DESCRIPTION OF THE INVENTION

An optical image capturing system of the present invention includes a first lens, a second lens, a third lens, a fourth lens, and a fifth lens from an object side to an image side. The optical image capturing system further is provided with an image sensor at an image plane.

The optical image capturing system works in three wavelengths, including 486.1 nm, 587.5 nm, and 656.2 nm, wherein 587.5 nm is the main reference wavelength, and 555 nm is adopted as the main reference wavelength for extracting features.

The optical image capturing system of the present invention satisfies  $0.5 \leq \Sigma PPR / |\Sigma NPR| \leq 2.5$ , and a preferable range is  $1 \leq \Sigma PPR / |\Sigma NPR| \leq 2.0$ , where PPR is a ratio of the focal length  $f$  of the optical image capturing system to a focal length  $f_p$  of each of lenses with positive refractive power; NPR is a ratio of the focal length  $f$  of the optical image capturing system to a focal length  $f_n$  of each of lenses with negative refractive power;  $\Sigma PPR$  is a sum of the PPRs of each positive lens, and  $\Sigma NPR$  is a sum of the NPRs of each negative lens. It is helpful to control of an entire refractive power and an entire length of the optical image capturing system.

HOS is a height of the optical image capturing system, and when the ratio of HOS/ $f$  approaches to 1, it is helpful for decrease of size and increase of imaging quality.

In an embodiment, the optical image capturing system of the present invention satisfies  $0 < \Sigma PP \leq 200$  and  $f_1 / \Sigma PP \leq 0.85$ , and a preferable range is  $0 < \Sigma PP \leq 150$  and  $0.01 \leq f_1 / \Sigma PP \leq 0.6$ , where  $\Sigma PP$  is a sum of a focal length  $f_p$  of each lens with positive refractive power, and  $\Sigma NP$  is a sum of a focal length  $f_n$  of each lens with negative refractive power. It is helpful to control of focusing capacity of the system and redistribution of the positive refractive powers of the system to avoid the significant aberration in early time. The optical image capturing system further satisfies  $\Sigma NP < -0.1$  and  $f_5 / \Sigma NP \leq 0.85$ , and preferably satisfies  $\Sigma NP < 0$  and  $0.01 \leq f_5 /$

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$\Sigma NP \leq 0.5$ , which is helpful to control of an entire refractive power and an entire length of the optical image capturing system.

The first lens has positive refractive power, and an object-side surface, which faces the object side, thereof can be convex. It may modify the positive refractive power of the first lens as well as shorten the entire length of the system.

The second lens can have negative refractive power, which may correct the aberration of the first lens.

The third lens can have positive refractive power, which may share the positive refractive power of the first lens.

The fourth lens can have negative refractive power, and an image-side surface thereof, which faces the image side, can be convex. The fourth lens may share the positive refractive power of the first lens to reduce an increase of the aberration and reduce a sensitivity of the system.

The fifth lens has negative refractive power, and an image-side surface thereof, which faces the image side, can be concave. It may shorten a rear focal length to reduce the size of the system. In addition, the fifth lens is provided with at least an inflection point on at least a surface to reduce an incident angle of the light of an off-axis field of view and modify the aberration of the off-axis field of view. It is preferable that each surface, the object-side surface and the image-side surface, of the fifth lens has at least an inflection point.

The image sensor is provided on the image plane. The optical image capturing system of the present invention satisfies  $HOS/HOI \leq 3$  and  $0.5 \leq HOS/f \leq 3.0$ , and a preferable range is  $1 \leq HOS/HOI \leq 2.5$  and  $1 \leq HOS/f \leq 2$ , where HOI is height for image formation of the optical image capturing system, i.e., the maximum image height, and HOS is a height of the optical image capturing system, i.e., a distance on the optical axis between the object-side surface of the first lens and the image plane. It is helpful for reduction of size of the system for used in compact cameras.

The optical image capturing system of the present invention further is provided with an aperture to increase image quality.

In the optical image capturing system of the present invention, the aperture could be a front aperture or a middle aperture, wherein the front aperture is provided between the object and the first lens, and the middle is provided between the first lens and the image plane. The front aperture provides a long distance between an exit pupil of the system and the image plane, which allows more elements to be installed. The middle could enlarge a view angle of view of the system and increase the efficiency of the image sensor. The optical image capturing system satisfies  $0.5 \leq \ln S / HOS \leq 1.1$ , and a preferable range is  $0.8 \leq \ln S / HOS \leq 1$ , where  $\ln S$  is a distance between the aperture and the image plane. It is helpful for size reduction and wide angle.

The optical image capturing system of the present invention satisfies  $0.45 \leq \Sigma TP / \ln TL \leq 0.95$ , where  $\ln TL$  is a distance between the object-side surface of the first lens and the image-side surface of the fifth lens, and  $\Sigma TP$  is a sum of central thicknesses of the lenses on the optical axis. It is helpful for the contrast of image and yield of manufacture, and provides a suitable back focal length for installation of other elements.

The optical image capturing system of the present invention satisfies  $0.1 \leq |R1/R2| \leq 5$ , and a preferable range is  $0.1 \leq |R1/R2| \leq 4$ , where  $R1$  is a radius of curvature of the object-side surface of the first lens, and  $R2$  is a radius of curvature of the image-side surface of the first lens. It provides the first lens with a suitable positive refractive power to reduce the increase rate of the spherical aberration.



The optical image capturing system of the present invention satisfies  $-200 < (R9 - R10) / (R9 + R10) < 30$ , where R9 is a radius of curvature of the object-side surface of the fifth lens, and R10 is a radius of curvature of the image-side surface of the fifth lens. It may modify the astigmatic field curvature.

The optical image capturing system of the present invention satisfies  $0 < IN12 / f \leq 0.25$ , and a preferable range is  $0.01 \leq IN12 / f \leq 0.20$ , where IN12 is a distance on the optical axis between the first lens and the second lens. It may correct chromatic aberration and improve the performance.

The optical image capturing system of the present invention satisfies  $1 \leq (TP1 + IN12) / TP2 \leq 10$ , where TP1 is a central thickness of the first lens on the optical axis, and TP2 is a central thickness of the second lens on the optical axis. It may control the sensitivity of manufacture of the system and improve the performance.

The optical image capturing system of the present invention satisfies  $0.2 \leq (TP5 + IN45) / TP4 \leq 3$ , where TP4 is a central thickness of the fourth lens on the optical axis, TP5 is a central thickness of the fifth lens on the optical axis, and IN45 is a distance between the fourth lens and the fifth lens. It may control the sensitivity of manufacture of the system and improve the performance.

The optical image capturing system of the present invention satisfies  $0.1 \leq (TP2 + TP3 + TP4) / \Sigma TP \leq 0.9$ , and a preferable range is  $0.4 \leq (TP2 + TP3 + TP4) / \Sigma TP \leq 0.8$ , where TP2 is a central thickness of the second lens on the optical axis, TP3 is a central thickness of the third lens on the optical axis, TP4 is a central thickness of the fourth lens on the optical axis, TP5 is a central thickness of the fifth lens on the optical axis, and  $\Sigma TP$  is a sum of the central thicknesses of all the lenses on the optical axis. It may finely modify the aberration of the incident rays and reduce the height of the system.

The optical image capturing system of the present invention satisfies  $-1.5 \text{ mm} \leq InRS51 \leq 1.5 \text{ mm}$ ;  $-1.5 \text{ mm} \leq InRS52 \leq 1.5 \text{ mm}$ ;  $0 \text{ mm} \leq |InRS51| + |InRS52| \leq 3 \text{ mm}$ ;  $0.01 \leq |InRS51| / TP5 \leq 10$ ; and  $0.01 \leq |InRS52| / TP5 \leq 10$ , where InRS51 is a displacement in parallel with the optical axis from a point on the object-side surface of the fifth lens, through which the optical axis passes, to a point at the maximum effective semi diameter of the object-side surface of the fifth lens, wherein InRS51 is positive while the displacement is toward the image side, and InRS51 is negative while the displacement is toward the object side; InRS52 is a displacement in parallel with the optical axis from a point on the image-side surface of the fifth lens, through which the optical axis passes, to a point at the maximum effective semi diameter of the image-side surface of the fifth lens; and TP5 is a central thickness of the fifth lens on the optical axis. It may control the positions of the maximum effective semi diameter on both surfaces of the fifth lens, correct the aberration of the spherical field of view, and reduce the size.

The optical image capturing system of the present invention satisfies  $0 < SGI511 / (SGI511 + TP5) \leq 0.9$  and  $0 < SGI521 / (SGI521 + TP5) \leq 0.9$ , and a preferable range is  $0.01 < SGI511 / (SGI511 + TP5) \leq 0.7$  and  $0.01 < SGI521 / (SGI521 + TP5) \leq 0.7$ , where SGI511 is a displacement in parallel with the optical axis from a point on the object-side surface of the fifth lens, through which the optical axis passes, to an inflection point, which is the closest to the optical axis, on the object-side surface of the fifth lens; SGI521 is a displacement in parallel with the optical axis from a point on the image-side surface of the fifth lens, through which the optical axis passes, to an inflection point, which is the closest to the optical axis, on the image-side surface of the fifth lens, and TP5 is a thickness of the fifth lens on the optical axis.

The optical image capturing system of the present invention satisfies  $0 < SGI512 / (SGI512 + TP5) \leq 0.9$  and  $0 < SGI522 / (SGI522 + TP5) \leq 0.9$ , and a preferable range is  $0.1 \leq SGI512 / (SGI512 + TP5) \leq 0.8$  and  $0.1 \leq SGI522 / (SGI522 + TP5) \leq 0.8$ , where SGI512 is a displacement in parallel with the optical axis from a point on the object-side surface of the fifth lens, through which the optical axis passes, to an inflection point, which is the second closest to the optical axis, on the image-side surface of the fifth lens, and SGI522 is a displacement in parallel with the optical axis from a point on the object-side surface of the fifth lens, through which the optical axis passes, to an inflection point, which is the second closest to the optical axis, on the image-side surface of the fifth lens.

The optical image capturing system of the present invention satisfies  $0.01 \leq HIF511 / HOI \leq 0.9$  and  $0.01 \leq HIF521 / HOI \leq 0.9$ , and a preferable range is  $0.09 \leq HIF511 / HOI \leq 0.5$  and  $0.09 \leq HIF521 / HOI \leq 0.5$ , where HIF511 is a distance perpendicular to the optical axis between the inflection point, which is the closest to the optical axis, on the object-side surface of the fifth lens and the optical axis, and HIF521 is a distance perpendicular to the optical axis between the inflection point, which is the closest to the optical axis, on the image-side surface of the fifth lens and the optical axis.

The optical image capturing system of the present invention satisfies  $0.01 \leq HIF512 / HOI \leq 0.9$  and  $0.01 \leq HIF522 / HOI \leq 0.9$ , and a preferable range is  $0.09 \leq HIF512 / HOI \leq 0.8$  and  $0.09 \leq HIF522 / HOI \leq 0.8$ , where HIF512 is a distance perpendicular to the optical axis between the inflection point, which is the second the closest to the optical axis, on the object-side surface of the fifth lens and the optical axis, and HIF522 is a distance perpendicular to the optical axis between the inflection point, which is the second the closest to the optical axis, on the image-side surface of the fifth lens and the optical axis.

In an embodiment, the lenses of high Abbe number and the lenses of low Abbe number are arranged in an interlaced arrangement that could be helpful for correction of aberration of the system.

An equation of aspheric surface is

$$z = ch^2 / [1 + [1 + (k+1)c^2h^2]^{0.5}] + A4h^4 + A6h^6 + A8h^8 + A10h^{10} + A12h^{12} + A14h^{14} + A16h^{16} + A18h^{18} + A20h^{20} \quad (1)$$

where z is a depression of the aspheric surface; k is conic constant; c is reciprocal of radius of curvature; and A4, A6, A8, A10, A12, A14, A16, A18, and A20 are high-order aspheric coefficients.

In the optical image capturing system, the lenses could be made of plastic or glass. The plastic lenses may reduce the weight and lower the cost of the system, and the glass lenses may control the thermal effect and enlarge the space for arrangement of refractive power of the system. In addition, the opposite surfaces (object-side surface and image-side surface) of the first to the fifth lenses could be aspheric that can obtain more control parameters to reduce aberration. The number of aspheric glass lenses could be less than the conventional spherical glass lenses that is helpful for reduction of the height of the system.

When the lens has a convex surface, which means that the surface is convex around a position, through which the optical axis passes, and when the lens has a concave surface, which means that the surface is concave around a position, through which the optical axis passes.

The optical image capturing system of the present invention further is provided with a diaphragm to increase image quality.

In the optical image capturing system, the diaphragm could be a front diaphragm or a middle diaphragm, wherein the front diaphragm is provided between the object and the first lens, and the middle is provided between the first lens and the image plane. The front diaphragm provides a long distance between an exit pupil of the system and the image plane, which allows more elements to be installed. The middle diaphragm could enlarge a view angle of view of the system and increase the efficiency of the image sensor. The middle diaphragm is helpful for size reduction and wide angle.

The optical image capturing system of the present invention could be applied in dynamic focusing optical system. It is superior in correction of aberration and high imaging quality so that it could be allied in lots of fields.

We provide several embodiments in conjunction with the accompanying drawings for the best understanding, which are:

#### First Embodiment

As shown in FIG. 1A and FIG. 1B, an optical image capturing system **100** of the first preferred embodiment of the present invention includes, along an optical axis from an object side to an image side, an aperture **100**, a first lens **110**, a second lens **120**, a third lens **130**, a fourth lens **140**, a fifth lens **150**, an infrared rays filter **170**, an image plane **180**, and an image sensor **190**.

The first lens **110** has positive refractive power, and is made of plastic. An object-side surface **112** thereof, which faces the object side, is a convex aspheric surface, and an image-side surface **114** thereof, which faces the image side, is a concave aspheric surface, and the image-side surface has an inflection point. The first lens **110** satisfies  $SGI121=0.0387148$  mm and  $|SGI121|/(|SGI121|+TP1)=0.061775374$ , where  $SGI121$  is a displacement in parallel with the optical axis from a point on the image-side surface of the first lens, through which the optical axis passes, to the inflection point on the image-side surface, which is the closest to the optical axis.

The first lens **110** further satisfies  $HIF121=0.61351$  mm and  $HIF121/HOI=0.209139253$ , where  $HIF121$  is a displacement perpendicular to the optical axis from a point on the image-side surface of the first lens, through which the optical axis passes, to the inflection point, which is the closest to the optical axis.

The second lens **120** has negative refractive power, and is made of plastic. An object-side surface **122** thereof, which faces the object side, is a concave aspheric surface, and an image-side surface **124** thereof, which faces the image side, is a convex aspheric surface, and the image-side surface **124** has an inflection point. The second lens **120** satisfies  $SGI221=-0.0657553$  mm and  $|SGI221|/(|SGI221|+TP2)=0.176581512$ , where  $SGI221$  is a displacement in parallel with the optical axis from a point on the image-side surface of the second lens, through which the optical axis passes, to the inflection point on the image-side surface, which is the closest to the optical axis.

The second lens further satisfies  $HIF221=0.84667$  mm and  $HIF221/HOI=0.288621101$ , where  $HIF221$  is a displacement perpendicular to the optical axis from a point on the image-side surface of the second lens, through which the optical axis passes, to the inflection point, which is the closest to the optical axis.

The third lens **130** has negative refractive power, and is made of plastic. An object-side surface **132**, which faces the object side, is a concave aspheric surface, and an image-side surface **134**, which faces the image side, is a convex aspheric surface, and each of them has two inflection points. The third lens **130** satisfies  $SGI311=-0.341027$  mm;  $SGI321=-0.231534$  mm and  $|SGI311|/(|SGI311|+TP3)=0.525237108$  and  $|SGI321|/(|SGI321|+TP3)=0.428934269$ , where  $SGI311$  is a displacement in parallel with the optical axis, from a point on the object-side surface of the third lens, through which the optical axis passes, to the inflection point on the object-side surface, which is the closest to the optical axis, and  $SGI321$  is a displacement in parallel with the optical axis, from a point on the image-side surface of the third lens, through which the optical axis passes, to the inflection point on the image-side surface, which is the closest to the optical axis.

The third lens **130** satisfies  $SGI312=-0.376807$  mm;  $SGI322=-0.382162$  mm;  $|SGI312|/(|SGI312|+TP5)=0.550033428$ ;  $|SGI322|/(|SGI322|+TP3)=0.55352345$ , where  $SGI312$  is a displacement in parallel with the optical axis, from a point on the object-side surface of the third lens, through which the optical axis passes, to the inflection point on the object-side surface, which is the second closest to the optical axis, and  $SGI322$  is a displacement in parallel with the optical axis, from a point on the image-side surface of the third lens, through which the optical axis passes, to the inflection point on the image-side surface, which is the second closest to the optical axis.

The third lens **130** further satisfies  $HIF311=0.987648$  mm;  $HIF321=0.805604$  mm;  $HIF311/HOI=0.336679052$ ; and  $HIF321/HOI=0.274622124$ , where  $HIF311$  is a distance perpendicular to the optical axis between the inflection point on the object-side surface of the third lens, which is the closest to the optical axis, and the optical axis, and  $HIF321$  is a distance perpendicular to the optical axis between the inflection point on the image-side surface of the third lens, which is the closest to the optical axis, and the optical axis.

The third lens **130** further satisfies  $HIF312=1.0493$  mm;  $HIF322=1.17741$  mm;  $HIF312/HOI=0.357695585$ ; and  $HIF322/HOI=0.401366968$ , where  $HIF312$  is a distance perpendicular to the optical axis between the inflection point on the object-side surface of the third lens, which is the second the closest to the optical axis, and the optical axis, and  $HIF322$  is a distance perpendicular to the optical axis, between the inflection point on the image-side surface of the third lens, which is the second the closest to the optical axis, and the optical axis.

The fourth lens **140** has positive refractive power, and is made of plastic. Both an object-side surface **142**, which faces the object side, and an image-side surface **144**, which faces the image side, thereof are convex aspheric surfaces, and the object-side surface **142** has an inflection point. The fourth lens **140** satisfies  $SGI411=0.0687683$  mm and  $|SGI411|/(|SGI411|+TP4)=0.118221297$ , where  $SGI411$  is a displacement in parallel with the optical axis from a point on the object-side surface of the fourth lens, through which the optical axis passes, to the inflection point on the object-side surface, which is the closest to the optical axis.

The fourth lens **140** further satisfies  $HIF411=0.645213$  mm and  $HIF411/HOI=0.21994648$ , where  $HIF411$  is a distance perpendicular to the optical axis between the inflection point on the object-side surface of the fourth lens, which is the closest to the optical axis, and the optical axis.

The fifth lens **150** has negative refractive power, and is made of plastic. Both an object-side surface **152**, which faces the object side, and an image-side surface **154**, which

faces the image side, thereof are concave aspheric surfaces. The object-side surface **152** has three inflection points, and the image-side surface **154** has an inflection point. The fifth lens **150** satisfies  $SGI511 = -0.236079$  mm;  $SGI521 = 0.023266$  mm;  $|SGI511|/(|SGI511|+TP5) = 0.418297214$ ; and  $|SGI521|/(|SGI521|+TP5) = 0.066177809$ , where  $SGI511$  is a displacement in parallel with the optical axis, from a point on the object-side surface of the fifth lens, through which the optical axis passes, to the inflection point on the object-side surface, which is the closest to the optical axis, and  $SGI521$  is a displacement in parallel with the optical axis, from a point on the image-side surface of the fifth lens, through which the optical axis passes, to the inflection point on the image-side surface, which is the closest to the optical axis.

The fifth lens **150** further satisfies  $SGI512 = -0.325042$  mm and  $|SGI512|/(|SGI512|+TP5) = 0.497505143$ , where  $SGI512$  is a displacement in parallel with the optical axis, from a point on the object-side surface of the fifth lens, through which the optical axis passes, to the inflection point on the object-side surface, which is the second closest to the optical axis.

The fifth lens **150** further satisfies  $SGI513 = -0.538131$  mm; and  $|SGI513|/(|SGI513|+TP5) = 0.621087839$ , where  $SGI513$  is a displacement in parallel with the optical axis, from a point on the object-side surface of the fifth lens, through which the optical axis passes, to the inflection point on the object-side surface, which is the third closest to the optical axis.

The fifth lens **150** further satisfies  $HIF511 = 1.21551$  mm;  $HIF521 = 0.575738$  mm;  $HIF511/HOI = 0.414354866$ ; and  $HIF521/HOI = 0.196263167$ , where  $HIF511$  is a distance perpendicular to the optical axis between the inflection point on the object-side surface of the fifth lens, which is the closest to the optical axis, and the optical axis, and  $HIF521$  is a distance perpendicular to the optical axis between the inflection point on the image-side surface of the fifth lens, which is the closest to the optical axis, and the optical axis.

The fifth lens **150** further satisfies  $HIF512 = 1.49061$  mm and  $HIF512/HOI = 0.508133629$ , where  $HIF512$  is a distance perpendicular to the optical axis between the inflection point on the object-side surface of the fifth lens, which is the second the closest to the optical axis, and the optical axis.

The fifth lens **150** further satisfies  $HIF513 = 2.00664$  mm and  $HIF513/HOI = 0.684042952$ , where  $HIF513$  is a distance perpendicular to the optical axis between the inflection point on the object-side surface of the fifth lens, which is the third closest to the optical axis, and the optical axis.

The infrared rays filter **170** is made of glass, and between the fifth lens **150** and the image plane **180**. The infrared rays filter **170** gives no contribution to the focal length of the system.

The optical image capturing system of the first preferred embodiment has the following parameters, which are  $f = 3.73172$  mm;  $f/HEP = 2.05$ ; and  $HAF = 37.5$  degrees and  $\tan(HAF) = 0.7673$ , where  $f$  is a focal length of the system;  $HAF$  is a half of the maximum field angle; and  $HEP$  is an entrance pupil diameter.

The parameters of the lenses of the first preferred embodiment are  $f1 = 3.7751$  mm;  $|f/f1| = 0.9885$ ;  $f5 = -3.6601$  mm;  $|f1| > f5$ ; and  $|f1/f5| = 1.0314$ , where  $f1$  is a focal length of the first lens **110**; and  $f5$  is a focal length of the fifth lens **150**.

The first preferred embodiment further satisfies  $|f2| + |f3| + |f4| = 77.3594$  mm;  $|f1| + |f5| = 7.4352$  mm; and  $|f2| + |f3| + |f4| > |f1| + |f5|$ , where  $f2$  is a focal length of the second lens **120**;  $f3$  is a focal length of the third lens **130**; and  $f4$  is a focal length of the fourth lens **140**.

The optical image capturing system of the first preferred embodiment further satisfies  $\Sigma PPR = f/f1 + f/f4 = 1.9785$ ;  $\Sigma NPR = f/f2 + f/f3 + f/f5 = -1.2901$ ;  $\Sigma PPR/|\Sigma NPR| = 1.5336$ ;  $|f/f1| = 0.9885$ ;  $|f/f2| = 0.0676$ ;  $|f/f3| = 0.2029$ ;  $|f/f4| = 0.9900$ ; and  $|f/f5| = 1.0196$ , where  $PPR$  is a ratio of a focal length  $f$  of the optical image capturing system to a focal length  $f_p$  of each of the lenses with positive refractive power; and  $NPR$  is a ratio of a focal length  $f$  of the optical image capturing system to a focal length  $f_n$  of each of lenses with negative refractive power.

The optical image capturing system of the first preferred embodiment further satisfies  $InTL + InB = HOS$ ;  $HOS = 4.5$  mm;  $HOI = 2.9335$  mm;  $HOS/HOI = 1.5340$ ;  $HOS/f = 1.2059$ ;  $InTL/HOS = 0.7597$ ;  $InS = 4.19216$  mm; and  $InS/HOS = 0.9316$ , where  $InTL$  is a distance between the object-side surface **112** of the first lens **110** and the image-side surface **154** of the fifth lens **150**;  $HOS$  is a height of the image capturing system, i.e., a distance between the object-side surface **112** of the first lens **110** and the image plane **180**;  $InS$  is a distance between the aperture **100** and the image plane **180**;  $HOI$  is height for image formation of the optical image capturing system, i.e., the maximum image height; and  $InB$  is a distance between the image-side surface **154** of the fifth lens **150** and the image plane **180**.

The optical image capturing system of the first preferred embodiment further satisfies  $\Sigma TP = 2.044092$  mm and  $\Sigma TP/InTL = 0.5979$ , where  $\Sigma TP$  is a sum of the thicknesses of the lenses **110-150** with refractive power. It is helpful for the contrast of image and yield of manufacture, and provides a suitable back focal length for installation of other elements.

The optical image capturing system of the first preferred embodiment further satisfies  $|R1/R2| = 0.3261$ , where  $R1$  is a radius of curvature of the object-side surface **112** of the first lens **110**, and  $R2$  is a radius of curvature of the image-side surface **114** of the first lens **110**. It provides the first lens with a suitable positive refractive power to reduce the increase rate of the spherical aberration.

The optical image capturing system of the first preferred embodiment further satisfies  $(R9 - R10)/(R9 + R10) = -2.9828$ , where  $R9$  is a radius of curvature of the object-side surface **152** of the fifth lens **150**, and  $R10$  is a radius of curvature of the image-side surface **154** of the fifth lens **150**. It may modify the astigmatic field curvature.

The optical image capturing system of the first preferred embodiment further satisfies  $\Sigma PP = f1 + f4 = 7.5444$  mm and  $f1/(f1 + f4) = 0.5004$ , where  $\Sigma PP$  is a sum of the focal lengths  $f_p$  of each lens with positive refractive power. It is helpful to share the positive refractive power of the first lens **110** to the other positive lens to avoid the significant aberration caused by the incident rays.

The optical image capturing system of the first preferred embodiment further satisfies  $\Sigma NP = f2 + f3 + f5 = -77.2502$  mm and  $f5/(f2 + f3 + f5) = 0.0474$ , where  $f2$ ,  $f3$ , and  $f5$  are focal lengths of the second, the third, and the fifth lenses, and  $\Sigma NP$  is a sum of the focal lengths  $f_n$  of each lens with negative refractive power. It is helpful to share the negative refractive power of the fifth lens **150** to other negative lenses to avoid the significant aberration caused by the incident rays.

The optical image capturing system of the first preferred embodiment further satisfies  $IN12 = 0.511659$  mm and  $IN12/f = 0.1371$ , where  $IN12$  is a distance on the optical axis between the first lens **110** and the second lens **120**. It may correct chromatic aberration and improve the performance.

The optical image capturing system of the first preferred embodiment further satisfies  $TP1 = 0.587988$  mm;  $TP2 = 0.306624$  mm; and  $(TP1 + IN12)/TP2 = 3.5863$ , where  $TP1$  is a central thickness of the first lens **110** on the optical

axis, and TP2 is a central thickness of the second lens **120** on the optical axis. It may control the sensitivity of manufacture of the system and improve the performance.

The optical image capturing system of the first preferred embodiment further satisfies  $TP4=0.5129$  mm;  $TP5=0.3283$  mm; and  $(TP5+IN45)/TP4=1.5095$ , where TP4 is a central thickness of the fourth lens **140** on the optical axis, TP5 is a central thickness of the fifth lens **150** on the optical axis, and IN45 is a distance on the optical axis between the fourth lens and the fifth lens. It may control the sensitivity of manufacture of the system and improve the performance.

The optical image capturing system of the first preferred embodiment further satisfies  $TP3=0.3083$  mm and  $(TP2+TP3+TP4)/\Sigma TP=0.5517$ , where TP2, TP3, and TP4 are thicknesses on the optical axis of the second, the third, and the fourth lenses, and  $\Sigma TP$  is a sum of the central thicknesses of all the lenses with refractive power on the optical axis. It may finely modify the aberration of the incident rays and reduce the height of the system.

The optical image capturing system of the first preferred embodiment further satisfies  $InRS51=-0.576871$  mm;  $InRS52=-0.555284$  mm;  $|InRS51|+|InRS52|=1.1132155$  mm;  $|InRS51|/TP5=1.7571$ ; and  $|InRS52|/TP5=1.691$ , where InRS51 is a displacement in parallel with the optical

axis from a point on the object-side surface **152** of the fifth lens, through which the optical axis passes, to a point at the maximum effective semi diameter of the object-side surface **152** of the fifth lens; InRS52 is a displacement in parallel with the optical axis from a point on the image-side surface **154** of the fifth lens, through which the optical axis passes, to a point at the maximum effective semi diameter of the image-side surface **154** of the fifth lens; and TP5 is a central thickness of the fifth lens **150** on the optical axis. It is helpful for manufacturing and shaping of the lenses, and is helpful to reduce the size.

The second lens **120** and the fifth lens **150** of the optical image capturing system of the first preferred embodiment have negative refractive power, and the optical image capturing system further satisfies  $NA5/NA2=2.5441$ , where NA2 is an Abbe number of the second lens **120**, and NA5 is an Abbe number of the fifth lens **150**. It may correct the aberration of the system.

The optical image capturing system of the first preferred embodiment further satisfies  $|TDT|=0.6343\%$  and  $|ODT|=2.5001\%$ , where TDT is TV distortion; and ODT is optical distortion.

The parameters of the lenses of the first embodiment are listed in Table 1 and Table 2.

TABLE 1

f = 3.73172 mm; f/HEP = 2.05; HAF = 37.5 deg; tan(HAF) = 0.7673							
Surface		Radius of curvature (mm)	Thickness (mm)	Material	Refractive index	Abbe number	Focal length (mm)
0	Object	plane	infinity				
1	Aperture	plane	-0.30784				
2	1 <sup>st</sup> lens	1.48285	0.587988	plastic	1.5441	56.1	3.77514
3		4.54742	0.511659				
4	2 <sup>nd</sup> lens	-9.33807	0.306624	plastic	1.6425	22.465	-55.2008
5		-12.8028	0.366935				
6	3 <sup>rd</sup> lens	-1.02094	0.308255	plastic	1.6425	22.465	-18.3893
7		-1.2492	0.05				
8	4 <sup>th</sup> lens	2.18916	0.512923	plastic	1.5441	56.1	3.7693
9		-31.3936	0.44596				
10	5 <sup>th</sup> lens	-2.86353	0.328302	plastic	1.514	57.1538	-3.6601
11		5.75188	0.3				
12	Filter	plane	0.2		1.517	64.2	
13		plane	0.58424				
14	Image plane	plane	-0.00289				

Reference wavelength: 555 nm

TABLE 2

Coefficients of the aspheric surfaces					
	Surface				
	2	3	4	5	6
k	-1.83479	-20.595808	16.674705	11.425456	-4.642191
A4	6.89867E-02	2.25678E-02	-1.11828E-01	-4.19899E-02	-7.09315E-02
A6	2.35740E-02	-6.17850E-02	-6.62880E-02	-1.88072E-02	9.65840E-02
A8	-4.26369E-02	5.82944E-02	-3.35190E-02	-6.98321E-02	-7.32044E-03
A10	5.63746E-03	-2.73938E-02	-7.28886E-02	-1.13079E-02	-8.96740E-02
A12	7.46740E-02	-2.45759E-01	4.05955E-02	6.79127E-02	-3.70146E-02
A14	-6.93116E-02	3.43401E-01	1.60451E-01	2.83769E-02	5.00641E-02
A16	-2.04867E-02	-1.28084E-01	1.24448E-01	-2.45035E-02	7.50413E-02
A18	1.99910E-02	-2.32031E-02	-1.94856E-01	2.90241E-02	-5.10392E-02
A20					
	Surface				
	7	8	9	10	11
k	-1.197201	-20.458388	-50	-2.907359	-50
A4	3.64395E-02	-1.75641E-02	-7.82211E-04	-1.58711E-03	-2.46339E-02

TABLE 2-continued

Coefficients of the aspheric surfaces					
A6	2.22356E-02	-2.87240E-03	-2.47110E-04	-3.46504E-03	6.61804E-04
A8	7.09828E-03	-2.56360E-04	-3.78130E-04	4.52459E-03	1.54143E-04
A10	5.05740E-03	7.39189E-05	-1.22232E-04	1.05841E-04	-2.83264E-05
A12	-4.51124E-04	-5.53116E-08	-1.50294E-05	-5.57252E-04	-5.78839E-06
A14	-1.84003E-03	8.16043E-06	-5.41743E-07	4.41714E-05	-2.91861E-07
A16	-1.28118E-03	2.10395E-06	2.98820E-07	1.80752E-05	8.25778E-08
A18	4.09004E-04	-1.21664E-06	2.73321E-07	-2.27031E-06	-9.87595E-09
A20					

The detail parameters of the first preferred embodiment are listed in Table 1, in which the unit of radius of curvature, thickness, and focal length are millimeter, and surface 0-14 indicates the surfaces of all elements in the system in sequence from the object side to the image side. Table 2 is the list of coefficients of the aspheric surfaces, in which A1-A20 indicate the coefficients of aspheric surfaces from the first order to the twentieth order of each aspheric surface. The following embodiments have the similar diagrams and tables, which are the same as those of the first embodiment, so we do not describe it again.

#### Second Embodiment

As shown in FIG. 2A and FIG. 2B, an optical image capturing system of the second preferred embodiment of the present invention includes, along an optical axis from an object side to an image side, a first lens 210, an aperture 200, a second lens 220, a third lens 230, a fourth lens 240, a fifth lens 250, an infrared rays filter 270, an image plane 280, and an image sensor 290.

The first lens 210 has positive refractive power, and is made of plastic. An object-side surface 212 thereof, which faces the object side, is a concave aspheric surface, and an image-side surface 214 thereof, which faces the image side, is a convex aspheric surface, and each of them has an inflection point respectively.

The second lens 220 has negative refractive power, and is made of plastic. An object-side surface 222 thereof, which faces the object side, is a convex aspheric surface, and an image-side surface 224 thereof, which faces the image side, is a concave aspheric surface.

The third lens 230 has positive refractive power, and is made of plastic. An object-side surface 232, which faces the object side, is a convex aspheric surface, and an image-side surface 234, which faces the image side, is a convex aspheric surface. The object-side surface 232 has an inflection point thereon.

The fourth lens 240 has negative refractive power, and is made of plastic. An object-side surface 242 thereof, which faces the object side, is a concave aspheric surface, and an image-side surface 244 thereof, which faces the image side, is a convex aspheric surface. The object-side surface 242 and the image-side surface 244 both have two inflection points thereon.

The fifth lens 250 has negative refractive power, and is made of plastic. An object-side surface 252 thereof, which faces the object side, is a convex aspheric surface, and an image-side surface 254 thereof, which faces the image side, is a concave aspheric surface. The object-side surface 252 and the image-side surface 254 both have an inflection point.

The infrared rays filter 270 is made of glass, and between the fifth lens 250 and the image plane 280. The infrared rays filter 270 gives no contribution to the focal length of the system.

The optical image capturing system of the second preferred embodiment has the following parameters, which are  $|f2|+|f3|+|f4|=114.8894$  mm;  $|f1|+|f5|=10.1200$  mm; and  $|f2|+|f3|+|f4|>|f1|+|f5|$ , where  $f1$  is a focal length of the first lens 210;  $f2$  is a focal length of the second lens 220;  $f3$  is a focal length of the third lens 230;  $f4$  is a focal length of the fourth lens 240; and  $f5$  is a focal length of the fifth lens 250.

The optical image capturing system of the second preferred embodiment further satisfies  $TP4=0.4410$  mm and  $TP5=0.5313$  mm, where  $TP4$  is a thickness of the fourth lens on the optical axis, and  $TP5$  is a thickness of the fifth lens on the optical axis.

In the second embodiment, the first and the third lenses 210, 230 are positive lenses, and their focal lengths are  $f1$  and  $f3$  respectively. The optical image capturing system of the second preferred embodiment further satisfies  $\Sigma PP=f1+f3=8.8653$  mm and  $f1/(f1+f3)=0.7708$ , where  $\Sigma PP$  is a sum of the focal lengths of each positive lens. It is helpful to share the positive refractive power of the first lens 210 to the other positive lens to avoid the significant aberration caused by the incident rays.

The optical image capturing system of the second preferred embodiment further satisfies  $\Sigma NP=f2+f4+f5=-116.1440$  mm and  $f5/(f2+f4+f5)=0.1107$ , where  $f2$ ,  $f4$  and  $f5$  are focal lengths of the second lens 220, the fourth lens 240, and the fifth lenses 250, and  $\Sigma NP$  is a sum of the focal lengths of each negative lens. It is helpful to share the negative refractive power of the fifth lens 250 to other negative lenses to avoid the significant aberration caused by the incident rays.

The parameters of the lenses of the second embodiment are listed in Table 3 and Table 4.

TABLE 3

f = 3.04499 mm; f/HEP = 1.4; HAF = 50.0014 deg; tan(HAF) = 1.1918							
Surface		Radius of curvature (mm)	Thickness (mm)	Material	Refractive index	Abbe number	Focal length (mm)
0	Object	plane	infinity				
1	1 <sup>st</sup> lens	-11.5199	0.633953	plastic	1.65	21.4	6.83352

TABLE 3-continued

f = 3.04499 mm; f/HEP = 1.4; HAF = 50.0014 deg; tan(HAF) = 1.1918						
Surface	Radius of curvature (mm)	Thickness (mm)	Material	Refractive index	Abbe number	Focal length (mm)
2	-3.29534	0.539549				
3	Aperture plane	-0.26732				
4	2 <sup>nd</sup> lens	5.32819	0.256081 plastic	1.514	56.8	-12.8556
5		2.90562	0.214751			
6	3 <sup>rd</sup> lens	5.76049	2.25 plastic	1.565	58	2.03175
7		-1.23591	0.068369			
8	4 <sup>th</sup> lens	-1.22369	0.44095 plastic	1.65	21.4	-100.002
9		-1.42488	0.43528			
10	5 <sup>th</sup> lens	20.15529	0.531272 plastic	1.583	30.2	-3.28643
11		1.74207	0.4			
12	Filter plane	0.2		1.517	64.2	
13	plane	0.369886				
14	Image plane	0.066676				

Reference wavelength: 555 nm. The clear aperture of the first surface is 1.7 mm; the clear aperture of the sixth surface is 1.0 mm

TABLE 4

Coefficients of the aspheric surfaces						
	Surface					
	1	2	4	5	6	7
k =	-32.111489	-29.043197	20.538497	2.893875	7.796234	
A4 =	1.70448E-02	5.44336E-02	2.36690E-01	1.25318E-01	-1.94309E-02	9.12064E-02
A6 =	8.58212E-03	-1.58941E-02	-2.84178E-01	-2.75917E-01	3.54828E-02	-3.25066E-02
A8 =	-4.73154E-03	8.98647E-03	1.97091E-01	2.44372E-01	-9.14755E-02	1.21732E-02
A10 =	1.82736E-03	2.30323E-03	-3.05007E-02	-5.88377E-02	-1.34040E-02	-7.31762E-04
A12 =	-4.01244E-04	-3.78821E-03	-4.55037E-02	-6.05169E-02	1.12767E-01	-1.42096E-03
A14 =	4.46980E-05	1.21091E-03	2.24753E-02	3.46406E-02	-6.98898E-02	4.50126E-04

	Surface			
	8	9	10	11
k =	-0.529239	-0.595565	-50	-5.806512
A4 =	2.85489E-02	2.23253E-02	-8.92450E-02	-2.98001E-02
A6 =	2.77193E-02	5.27678E-03	2.78230E-02	5.50570E-03
A8 =	-7.88676E-04	5.95196E-03	-8.37179E-03	-8.32298E-04
A10 =	-7.39920E-04	-1.24426E-03	-4.17360E-05	4.58552E-05
A12 =	2.04814E-04	1.84562E-04	6.66916E-04	2.88566E-06
A14 =	7.88900E-05	-3.09911E-05	-1.11326E-04	-3.94115E-07

An equation of the aspheric surfaces of the second embodiment is the same as that of the first embodiment, and the definitions are the same as well.

The exact parameters of the second embodiment (with 555 nm as the main reference wavelength) based on Table 3 and Table 4 are listed in the following table:

TDT	1.0832%	InRS41	-0.8325
ODT	1.9986%	InRS42	-0.7040
ΣPP	8.8653	InRS51	-0.8519
ΣNP	-116.1440	InRS52	-0.4117
f1/ΣPP	0.7708	InRS51 /TP5	1.4205
f5/ΣNP	0.1107	InRS52 /TP5	0.6866
In12/f	0.0894	( InRS42  +  InRS51 )/ IN45	3.5744
HOS/f	2.0162	HVT51	0.3839
HOS	6.1394	HVT52	1.8828

-continued

50	InTL	5.1029	HVT51/HOI	0.1026
	HOS/HOI	1.6416	HVT52/HOI	0.5034
	InS/HOS	0.8089	HVT52/HOS	0.3067
55	InTL/HOS	0.8312	f/f1	0.4456
	ΣTP/InTL	0.8059	f/f2	0.2369
	(TP1 + IN12)/TP2	3.5386	f/f3	1.4987
	(TP5 + IN45)/TP4	2.1920	f/f4	0.0304
60	(TP2 + TP3 + TP4)/ΣTP	0.7166	f/f5	0.9265

The exact parameters related to inflection points of the second embodiment (with main reference wavelength as 555 nm) based on Table 3 and Table 4 are listed in the following table:

HIF111	0.54717	HIF111/HOI	0.14630	SGI111	-0.01105	$ SGI111 /( SGI111  + TP1)$	0.01713
HIF121	0.50238	HIF121/HOI	0.13433	SGI121	-0.03027	$ SGI121 /( SGI121  + TP1)$	0.04557
HIF311	0.65171	HIF311/HOI	0.17425	SGI311	0.03451	$ SGI311 /( SGI311  + TP3)$	0.05162
HIF411	1.16832	HIF411/HOI	0.31239	SGI411	-0.51592	$ SGI411 /( SGI411  + TP4)$	0.44868
HIF412	1.60870	HIF412/HOI	0.43013	SGI412	-0.80388	$ SGI412 /( SGI412  + TP4)$	0.55909
HIF421	1.14342	HIF421/HOI	0.30573	SGI421	-0.43001	$ SGI421 /( SGI421  + TP4)$	0.40416
HIF422	1.81927	HIF422/HOI	0.48644	SGI422	-0.70301	$ SGI422 /( SGI422  + TP4)$	0.52583
HIF511	0.21828	HIF511/HOI	0.05836	SGI511	0.00098	$ SGI511 /( SGI511  + TP5)$	0.00154
HIF521	0.84145	HIF521/HOI	0.22499	SGI521	0.15227	$ SGI521 /( SGI521  + TP5)$	0.19367

### Third Embodiment

As shown in FIG. 3A and FIG. 3B, an optical image capturing system of the third preferred embodiment of the present invention includes, along an optical axis from an object side to an image side, a first lens 310, an aperture 300, a second lens 320, a third lens 330, a fourth lens 340, a fifth lens 350, an infrared rays filter 370, an image plane 380, and an image sensor 390.

The first lens 310 has positive refractive power, and is made of plastic. An object-side surface 312 thereof, which faces the object side, is a convex aspheric surface, and an image-side surface 314 thereof, which faces the image side, is a concave aspheric surface. The object-side surface 312 and the image-side surface 314 both have an inflection point thereon.

The second lens 320 has negative refractive power, and is made of plastic. An object-side surface 322 thereof, which faces the object side, is a convex aspheric surface; while an image-side surface 324 thereof, which faces the image side, is a concave aspheric surface. The object-side surface 322 and the image-side surface 324 both have an inflection point thereon.

The third lens 330 has positive refractive power, and is made of plastic. An object-side surface 332, which faces the object side, is a concave aspheric surface, and an image-side surface 334, which faces the image side, is a convex aspheric surface.

The fourth lens 340 has a negative refractive power, and is made of plastic. An object-side surface 342, which faces the object side, is a concave aspheric surface, and an image-side surface 344, which faces the image side, is a convex aspheric surface. The object-side surface 342 has two inflection points thereon.

The fifth lens 350 has negative refractive power, and is made of plastic. Both an object-side surface 352, which

faces the object side, and an image-side surface 354, which faces the image side, thereof are concave aspheric surfaces. The object-side surface 352 has two inflection points, and the image-side surface 354 has an inflection point.

The infrared rays filter 370 is made of glass, and between the fifth lens 350 and the image plane 380. The infrared rays filter 370 gives no contribution to the focal length of the system.

The parameters of the lenses of the third preferred embodiment are  $|f2|+|f3|+|f4|=109.5899$  mm;  $|f1|+|f5|=8.8602$  mm; and  $|f2|+|f3|+|f4|>|f1|+|f5|$ , where  $f1$  is a focal length of the first lens 310;  $f2$  is a focal length of the second lens 320;  $f3$  is a focal length of the third lens 330; and  $f4$  is a focal length of the fourth lens 340; and  $f5$  is a focal length of the fifth lens 350.

The optical image capturing system of the third preferred embodiment further satisfies  $TP4=0.5368$  mm and  $TP5=0.3381$  mm, where  $TP4$  is a thickness of the fourth lens 340 on the optical axis, and  $TP5$  is a thickness of the fifth lens 350 on the optical axis.

The optical image capturing system of the third preferred embodiment further satisfies  $\Sigma PP=f1+f3=7.7668$  mm and  $f1/(f1+f3)=0.7975$ , where  $\Sigma PP$  is a sum of the focal lengths of each positive lens. It is helpful to share the positive refractive power of the first lens 310 to the other positive lens to avoid the significant aberration caused by the incident rays.

The optical image capturing system of the third preferred embodiment further satisfies  $\Sigma NP=f2+f4+f5=-110.6832$  mm and  $f5/(f2+f4+f5)=0.9035$ , where  $\Sigma NP$  is a sum of the focal lengths of each negative lens. It is helpful to share the negative refractive power of the fifth lens 350 to other lenses with negative refractive power.

The parameters of the lenses of the third embodiment are listed in Table 5 and Table 6.

TABLE 5

f = 3.12928 mm; f/HEP = 1.6; HAF = 49.9989 deg; tan(HAF) = 1.1917							
Surface		Radius of curvature (mm)	Thickness (mm)	Material	Refractive index	Abbe number	Focal length (mm)
0	Object	plane	infinity				
1	1st lens	2.17479	0.439545	plastic	1.565	30.2	6.19403
2		5.01406	0.143529				
3	Aperture	plane	0.391924				
4	2 <sup>nd</sup> lens	21.87254	0.807168	plastic	1.565	58	-100
5		15.5714	0.198468				
6	3 <sup>rd</sup> lens	-10.4212	0.640669	plastic	1.565	58	1.57278
7		-0.83944	0.051804				
8	4 <sup>th</sup> lens	-1.01884	0.536834	plastic	1.565	26.6	-8.01707
9		-1.54344	0.683804				
10	5 <sup>th</sup> lens	-3.49326	0.338125	plastic	1.65	26.6	-2.66616
11		3.16565	0.3				
12	Filter	plane	0.2		1.517	64.2	

TABLE 5-continued

f = 3.12928 mm; f/HEP = 1.6; HAF = 49.9989 deg; tan(HAF) = 1.1917						
Surface	Radius of curvature (mm)	Thickness (mm)	Material	Refractive index	Abbe number	Focal length (mm)
13	plane	0.246045				
14	Image plane	0.084534				

Reference wavelength: 555 nm. The clear aperture of the second surface is 1.15 mm; the clear aperture of the sixth surface is 1.4 mm

TABLE 6

Coefficients of the aspheric surfaces						
	Surface					
	1	2	4	5	6	7
k =	-14.410401	-27.502948	50	6.437629	38.56702	-2.357464
A4 =	1.54287E-01	4.25401E-02	-8.89025E-02	-4.61798E-02	-1.12970E-01	1.81107E-02
A6 =	-9.29394E-02	-5.19366E-02	9.02399E-02	-1.12820E-02	1.08679E-02	-1.57741E-02
A8 =	2.58799E-02	4.23595E-02	-1.61847E-01	-1.08748E-03	7.76558E-04	6.40568E-03
A10 =	2.28794E-02	1.79752E-02	3.72701E-02	-4.01437E-03	9.34479E-04	1.24315E-03
A12 =	-1.57336E-02	-6.17245E-02	9.09078E-02	-5.56028E-03	-7.06209E-04	-2.87684E-04
A14 =	2.20896E-05	2.49091E-02	-7.44749E-02	1.56050E-03	-5.68331E-04	-5.07523E-04

	Surface			
	8	9	10	11
k	-2.236569	-0.498113	-1.402819	-14.974414
A4	1.23225E-01	6.71654E-03	-6.65366E-02	-2.32053E-02
A6	-1.26790E-02	6.90319E-03	2.01675E-02	2.95881E-03
A8	-2.22656E-02	3.26373E-04	-9.13378E-04	-2.22849E-04
A10	4.04064E-03	-1.81551E-04	-3.57198E-04	9.89530E-06
A12	3.16419E-03	-4.85787E-05	7.54275E-05	2.46777E-07
A14	-1.38314E-03	1.18225E-06	-6.96187E-06	-8.80462E-08

An equation of the aspheric surfaces of the third embodiment is the same as that of the first embodiment, and the definitions are the same as well.

The exact parameters of the third embodiment (with 555 nm as the main reference wavelength) based on Table 5 and Table 6 are listed in the following table:

TDT	1.3431%	InRS41	-0.8779
ODT	2.0776%	InRS42	-1.1739
ΣPP	7.7668	InRS51	-1.0157
ΣNP	-110.6832	InRS52	-0.4889
f1/ΣPP	0.7975	InRS51 /TP5	1.6936
f5/ΣNP	0.9035	InRS52 /TP5	0.8152
IN12/f	0.1711	( InRS42  +  InRS51 )/IN45	3.2020

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-continued

HOS/f	1.6178	HVT51	0
HOS	5.0625	HVT52	1.6048
InTL	4.2319	HVT51/HOI	0
HOS/HOI	1.3536	HVT52/HOI	0.4291
InS/HOS	0.8848	HVT52/HOS	0.3170
InTL/HOS	0.8359	f/f1	0.5052
ΣTP/InTL	0.6527	f/f2	0.0313
(TP1 + IN12)/TP2	1.2079	f/f3	1.9896
(TP5 + IN45)/TP4	1.9036	f/f4	0.3903
(TP2 + TP3 + TP4)/ΣTP	0.7185	f/f5	1.1737

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The exact parameters related to inflection points of the second embodiment (with main reference wavelength as 555 nm) based on Table 5 and Table 6 are listed in the following table:

HIF111	1.08504	HIF111/HOI	0.29012	SGI111	0.29743	SGI111 /( SGI111  + TP1)	0.40358
HIF121	0.85686	HIF121/HOI	0.22911	SGI121	0.07451	SGI121 /( SGI121  + TP1)	0.14495
HIF211	0.21938	HIF211/HOI	0.05866	SGI211	0.00090	SGI211 /( SGI211  + TP2)	0.00205
HIF221	0.33007	HIF221/HOI	0.08825	SGI221	0.00294	SGI221 /( SGI221  + TP2)	0.00664
HIF411	0.68404	HIF411/HOI	0.18290	SGI411	-0.17957	SGI411 /( SGI411  + TP4)	0.29004
HIF412	1.04281	HIF412/HOI	0.27883	SGI412	-0.31721	SGI412 /( SGI412  + TP4)	0.41917
HIF511	1.49205	HIF511/HOI	0.39894	SGI511	-0.45491	SGI511 /( SGI511  + TP5)	0.50859
HIF512	1.95532	HIF512/HOI	0.52281	SGI512	-0.71100	SGI512 /( SGI512  + TP5)	0.61797
HIF521	0.75369	HIF521/HOI	0.20152	SGI521	0.06976	SGI521 /( SGI521  + TP5)	0.13697



As shown in FIG. 4A and FIG. 4B, an optical image capturing system of the fourth preferred embodiment of the present invention includes, along an optical axis from an object side to an image side, an aperture **400**, a first lens **410**, a second lens **420**, a third lens **430**, a fourth lens **440**, a fifth lens **450**, an infrared rays filter **470**, an image plane **480**, and an image sensor **490**.

The first lens **410** has positive refractive power, and is made of plastic. An object-side surface **412** thereof, which faces the object side, is a convex aspheric surface, and an image-side surface **414** thereof, which faces the image side, is a convex aspheric surface. The image-side surface **414** has an inflection point thereon.

The second lens **420** has negative refractive power, and is made of plastic. An object-side surface **422** thereof, which faces the object side, is a convex aspheric surface, and an image-side surface **424** thereof, which faces the image side, is a concave aspheric surface. The image-side surface **424** has an inflection point.

The third lens **430** has positive refractive power, and is made of plastic. An object-side surface **432**, which faces the object side, is a concave aspheric surface, and an image-side surface **434**, which faces the image side, is a convex aspheric surface.

The fourth lens **440** has negative refractive power, and is made of plastic. An object-side surface **442**, which faces the object side, is a concave aspheric surface, and an image-side surface **444**, which faces the image side, is a convex aspheric surface. The object-side surface **442** and the image-side surface **444** both have an inflection point.

The fifth lens **450** has negative refractive power, and is made of plastic. An object-side surface **452** thereof, which faces the object side, is a convex aspheric surface, and an

image-side surface **454** thereof, which faces the image side, is a concave aspheric surface, and each of them has an inflection point.

The infrared rays filter **470** is made of glass, and between the fifth lens **450** and the image plane **480**. The infrared rays filter **470** gives no contribution to the focal length of the system.

The optical image capturing system of the fourth preferred embodiment has the following parameters, which are  $|f2|+|f3|+|f4|=203.9003$  mm;  $|f1|+|f5|=22.2372$  mm; and  $|f2|+|f3|+|f4|>|f1|+|f5|$ , where  $f1$  is a focal length of the first lens **410**;  $f2$  is a focal length of the second lens **420**;  $f3$  is a focal length of the third lens **430**;  $f4$  is a focal length of the fourth lens **440**; and  $f5$  is a focal length of the fifth lens **450**.

The optical image capturing system of the fourth preferred embodiment further satisfies  $TP4=0.9894$  mm and  $TP5=1.2227$  mm, where  $TP4$  is a thickness of the fourth lens on the optical axis, and  $TP5$  is a thickness of the fifth lens on the optical axis.

In the fourth embodiment, the first and the third lenses **410**, **430** are positive lenses, and their focal lengths are  $f1$  and  $f3$  respectively. The optical image capturing system of the fourth preferred embodiment further satisfies  $\Sigma PP=f1+f3=9.5002$  mm and  $f1/(f1+f3)=0.5894$ , where  $\Sigma PP$  is a sum of the focal lengths of each positive lens. It is helpful to share the positive refractive power of the first lens **410** to the other positive lens to avoid the significant aberration caused by the incident rays.

The optical image capturing system of the fourth preferred embodiment further satisfies  $\Sigma NP=f2+f4+f5=-216.6373$  mm and  $f5/(f2+f4+f5)=0.4616$ , where  $f2$ ,  $f4$  and  $f5$  are focal lengths of the second, the fourth and the fifth lenses **420**, **440**, **450**, and  $\Sigma NP$  is a sum of the focal lengths of each negative lens. It is helpful to share the negative refractive power of the fifth lens **450** to other negative lenses to avoid the significant aberration caused by the incident rays.

The parameters of the lenses of the fourth embodiment are listed in Table 7 and Table 8.

TABLE 7

f = 3.01798 mm; f/HEP = 1.8; HAF = 50.0004 deg; tan(HAF) = 1.1919							
Surface		Radius of curvature (mm)	Thickness (mm)	Material	Refractive index	Abbe number	Focal length (mm)
0	Object	plane	infinity				
1	1 <sup>st</sup> lens	3.75369	0.4562	plastic	1.65	21.4	5.59985
2		-157.435	0.113279				
3	Aperture	plane	-0.06648				
4	2 <sup>nd</sup> lens	28.90376	0.320317	plastic	1.514	56.8	-100
5		18.45196	0.201419				
6	3 <sup>rd</sup> lens	-31.8535	0.659507	plastic	1.565	58	3.90033
7		-2.08265	0.205949				
8	4 <sup>th</sup> lens	-1.26402	0.989365	plastic	1.607	26.6	-100
9		-1.67392	0.22823				
10	5 <sup>th</sup> lens	2.3755	1.222658	plastic	1.65	21.4	-16.6373
11		1.55309	0.6				
12	Filter	plane	0.2		1.517	64.2	
13		plane	0.195782				
14	Image plane	plane	0.096747				

TABLE 8

Coefficients of the aspheric surfaces						
	Surface					
	1	2	4	5	6	7
k =	-8.042882	50	-50	-47.982794	50	-26.437942
A4 =	6.82441E-03	1.30006E-01	1.99202E-01	5.30446E-06	-9.18258E-02	-3.38060E-01
A6 =	5.97843E-02	2.24690E-01	-1.37348E-01	-1.93461E-01	2.72351E-01	3.40964E-01
A8 =	-9.56620E-02	-1.34470E+00	-5.66653E-02	2.40029E-01	-1.23632E+00	-2.61390E-01
A10 =	9.72689E-02	3.39344E+00	4.89504E-01	-8.80032E-02	2.19953E+00	-2.16524E-01
A12 =	-5.24899E-02	-4.04253E+00	-8.06183E-01	-4.32311E-01	-1.96382E+00	3.49961E-01
A14 =	1.21078E-02	1.93995E+00	5.17467E-01	4.28065E-01	5.82683E-01	-1.40299E-01

	Surface			
	8	9	10	11
k	0.13763	-0.321395	-37.255342	-6.398451
A4	5.12102E-02	-1.73098E-01	-6.68346E-02	-2.17676E-02
A6	-1.99088E-01	2.26228E-01	1.16924E-02	2.88036E-03
A8	4.32664E-01	-1.85927E-01	-3.24423E-03	-2.62255E-04
A10	-6.02790E-01	9.15231E-02	3.68664E-04	2.75067E-06
A12	3.21026E-01	-2.53160E-02	-3.20460E-05	9.15856E-07
A14	-1.49719E-02	3.44062E-03	1.84028E-06	-4.79682E-08

An equation of the aspheric surfaces of the fourth embodiment is the same as that of the first embodiment, and the definitions are the same as well.

The exact parameters of the fourth embodiment (with 555 nm as the main reference wavelength) based on Table 7 and Table 8 are listed in the following table:

TDT	0.2212%	InRS51	-0.6850
ODT	2.0284%	InRS52	-0.8720
ΣPP	9.5002	InRS51 /TP5	-0.3890
ΣNP	-216.6373	InRS52 /TP5	0.0034
f1/ΣPP	0.5894	HIF511	0.6487
f5/ΣNP	0.4616	HIF512	0.0056
IN12/f	0.0155	HIF521	5.5250
HOS/f	1.7969	HIF522	0.8731
HOS	5.4230	HIF311	2.0611
InTL	4.3305	HIF312	0.2334
HOS/HOI	1.4500	HIF321	0.5511
InS/HOS	0.8950	HIF322	0.3801
InTL/HOS	0.7985	f/f1	0.5389
ΣTP/InTL	0.8424	f/f2	0.0302
(TP1 + IN12)/TP2	1.5703	f/f3	0.7738
(TP5 + IN45)/TP5	1.4665	f/f4	0.0302
(TP2 + TP3 + TP4)/ΣTP	0.5398	f/f5	0.1814

The exact parameters related to inflection points of the second embodiment (with main reference wavelength as 555 nm) based on Table 7 and Table 8 are listed in the following table:

HIF121	0.06326	HIF121/HOI	0.01691	SGI121	-0.00001	SGI121 /( SGI121  + TP1)	0.00002
HIF211	0.32945	HIF211/HOI	0.08809	SGI211	0.00271	SGI211 /( SGI211  + TP2)	0.00591
HIF212	0.85797	HIF212/HOI	0.22940	SGI212	-0.02489	SGI212 /( SGI212  + TP2)	0.05174
HIF411	1.01806	HIF411/HOI	0.27221	SGI411	-0.55195	SGI411 /( SGI411  + TP4)	0.54749
HIF421	1.29897	HIF421/HOI	0.34732	SGI421	-0.68143	SGI421 /( SGI421  + TP4)	0.59899
HIF511	0.42332	HIF511/HOI	0.11319	SGI511	0.02850	SGI511 /( SGI511  + TP5)	0.05880
HIF521	0.85509	HIF521/HOI	0.22863	SGI521	0.16885	SGI521 /( SGI521  + TP5)	0.27014

#### Fifth Embodiment

As shown in FIG. 5A and FIG. 5B, an optical image capturing system of the fifth preferred embodiment of the present invention includes, along an optical axis from an object side to an image side, a first lens 510, an aperture 500,

a second lens 520, a third lens 530, a fourth lens 540, a fifth lens 550, an infrared rays filter 570, an image plane 580, and an image sensor 590.

The first lens 510 has positive refractive power, and is made of plastic. An object-side surface 512 thereof, which faces the object side, is a convex aspheric surface, and an image-side surface 514 thereof, which faces the image side, is a concave aspheric surface.

The second lens 520 has negative refractive power, and is made of plastic. An object-side surface 522 thereof, which faces the object side, is a convex aspheric surface, and an image-side surface 524 thereof, which faces the image side, is a concave aspheric surface. The object-side surface 522 and the image-side surface 524 both have an inflection point thereon.

The third lens 530 has positive refractive power, and is made of plastic. An object-side surface 532, which faces the object side, is a convex aspheric surface, and an image-side surface 534, which faces the image side, is a convex aspheric surface. The object-side surface 532 has an inflection point.

The fourth lens 540 has a negative refractive power, and is made of plastic. An object-side surface 542, which faces the object side, is a concave aspheric surface, and an image-side surface 544, which faces the image side, is a convex aspheric surface. The image-side surface 544 has an inflection point thereon.

The fifth lens 550 has negative refractive power, and is made of plastic. An object-side surface 552, which faces the object side, is a concave aspheric surface, and an image-side surface 554, which faces the image side, thereof is a concave aspheric surface. The image-side surface 554 has an inflection point thereon.

The infrared rays filter **570** is made of glass, and between the fifth lens **550** and the image plane **580**. The infrared rays filter **570** gives no contribution to the focal length of the system.

The parameters of the lenses of the fifth preferred embodiment are  $|f2|+|f3|+|f4|=108.0843$  mm;  $|f1|+|f5|=8.2967$  mm; and  $|f2|+|f3|+|f4|>|f1|+|f5|$ , where  $f1$  is a focal length of the first lens **510**;  $f2$  is a focal length of the second lens **520**;  $f3$  is a focal length of the third lens **530**; and  $f4$  is a focal length of the fourth lens **540**; and  $f5$  is a focal length of the fifth lens **550**.

The optical image capturing system of the fifth preferred embodiment further satisfies  $TP4=0.5988$  mm and  $TP5=0.3481$  mm, where  $TP4$  is a thickness of the fourth lens **540** on the optical axis, and  $TP5$  is a thickness of the fifth lens **550** on the optical axis.

The optical image capturing system of the fifth preferred embodiment further satisfies  $\Sigma PP=f1+f3=7.5999$  mm and  $f1/(f1+f3)=0.7905$ , where  $\Sigma PP$  is a sum of the focal lengths of each positive lens. It is helpful to share the positive refractive power of the first lens **510** to the other positive lens to avoid the significant aberration caused by the incident rays.

The optical image capturing system of the fifth preferred embodiment further satisfies  $\Sigma NP=f2+f4+f5=-108.7810$  mm; and  $f5/(f2+f4+f5)=0.0597$ , where  $\Sigma NP$  is a sum of the focal lengths of each negative lens. It is helpful to share the negative refractive power of the fifth lens **550** to other negative lenses.

The parameters of the lenses of the fifth embodiment are listed in Table 9 and Table 10.

TABLE 9

f = 3.06494 mm; f/HEP = 2.0; HAF = 50 deg; tan(HAF) = 1.1918						
Surface	Radius of curvature (mm)	Thickness (mm)	Material	Refractive index	Abbe number	Focal length (mm)
0	Object plane	infinity				
1	1 <sup>st</sup> lens	3.66747	0.431952 plastic	1.632	23.4	6.00737
2		84.562	0.069027			
3	Aperture plane	-0.01908				
4	2 <sup>nd</sup> lens	2.69269	0.2 plastic	1.607	23.4	-6.49171
5		1.55934	0.100242			
6	3 <sup>rd</sup> lens	4.70055	2.25 plastic	1.565	58	1.59254
7		-0.9237	0.05			
8	4 <sup>th</sup> lens	-1.04152	0.598757 plastic	1.65	21.4	-100
9		-1.29923	0.585336			
10	5 <sup>th</sup> lens	-3.36408	0.348098 plastic	1.607	23.4	-2.28928
11		2.49287	0.5			
12	Filter plane	0.2		1.517	64.2	
13	plane	0.187776				
14	Image plane	0.067146				

Reference wavelength: 555 nm

TABLE 10

Coefficients of the aspheric surfaces						
	Surface					
	1	2	4	5	6	7
k =	-20.409862	-50	-25.275868	-10.360545	15.506475	-1.645885
A4 =	8.72174E-02	1.82767E-01	-6.50662E-02	1.40014E-03	-3.72628E-02	6.80061E-02
A6 =	1.86456E-01	-3.08069E-01	2.56544E-01	-5.81609E-02	3.26572E-02	-5.70807E-02
A8 =	-6.39583E-01	1.58756E+00	-9.80983E-01	1.80683E-01	1.28574E-01	8.54659E-03
A10 =	1.16587E+00	-4.39910E+00	1.51705E+00	-5.94848E-01	-4.63607E-01	1.64631E-03
A12 =	-1.01280E+00	6.21485E+00	-1.09419E+00	7.61806E-01	4.88346E-01	-1.35234E-03
A14 =	3.60468E-01	-3.31305E+00	2.97785E-01	-3.55213E-01	-1.85360E-01	2.38182E-04
	Surface					
	8	9	10	11		
k	-1.405897	-0.666247	0.996858	-5.109491		
A4	-1.32198E-02	-4.25923E-03	1.02826E-02	-2.56356E-02		
A6	5.70140E-03	1.40484E-02	-1.41432E-02	2.23066E-03		
A8	-2.17676E-03	2.25448E-03	3.68819E-03	-1.30581E-04		
A10	1.30469E-03	3.95482E-06	-5.04344E-04	-6.10154E-07		
A12	6.51734E-04	-4.82939E-05	1.09487E-04	-1.25194E-07		
A14	-3.69938E-04	-1.45207E-06	-2.43801E-05	-2.78538E-08		

An equation of the aspheric surfaces of the fifth embodiment is the same as that of the first embodiment, and the definitions are the same as well.

The exact parameters of the fifth embodiment (with 555 nm as the main reference wavelength) based on Table 9 and Table 10 are listed in the following table:

TDT	1.2047%	InRS51	-0.9424
ODT	1.7653%	InRS52	-0.9303
ΣPP	7.5999	InRS51 /TP5	-1.0443
ΣNP	-108.7810	InRS52 /TP5	-0.4238
f1/ΣPP	0.7905	HIF511	1.7413
f5/ΣNP	0.0597	HIF512	0.7067
IN12/f	0.0163	HIF521	3.3735
HOS/f	1.8171	HIF522	0
HOS	5.5693	HIF311	1.7902
InTL	4.6143	HIF312	0
HOS/HOI	1.4891	HIF321	0.4787
InS/HOS	0.9100	HIF322	0.3214
InTL/HOS	0.8285	f/f1	0.5102
ΣTP/InTL	0.8298	f/f2	0.4721
(TP1 + IN12)/TP2	2.4095	f/f3	1.9246
(TP5 + IN45)/TP5	1.5590	f/f4	0.0306
(TP2 + TP3 + TP4)/ΣTP	0.7963	f/f5	1.3388

The exact parameters related to inflection points of the second embodiment (with main reference wavelength as 555 nm) based on Table 9 and Table 10 are listed in the following table:

HIF211	0.48874	HIF211/HOI	0.13068	SGI211	0.03546	SGI211 /( SGI211  + TP2)	0.07587
HIF221	0.59692	HIF221/HOI	0.15961	SGI221	0.08830	SGI221 /( SGI221  + TP2)	0.16973
HIF311	0.88930	HIF311/HOI	0.23778	SGI311	0.08594	SGI311 /( SGI311  + TP3)	0.16595
HIF421	1.24150	HIF421/HOI	0.33195	SGI421	-0.59352	SGI421 /( SGI421  + TP4)	0.57878
HIF521	0.90250	HIF521/HOI	0.24131	SGI521	0.12998	SGI521 /( SGI521  + TP5)	0.23131

### Sixth Embodiment

As shown in FIG. 6A and FIG. 6B, an optical image capturing system of the sixth preferred embodiment of the present invention includes, along an optical axis from an object side to an image side, a first lens 610, an aperture 600, a second lens 620, a third lens 630, a fourth lens 640, a fifth lens 650, an infrared rays filter 670, an image plane 680, and an image sensor 690.

The first lens 610 has positive refractive power, and is made of plastic. An object-side surface 612, which faces the object side, is a convex aspheric surface, and an image-side surface 614 thereof, which faces the image side, is a concave aspheric surface.

The second lens 620 has negative refractive power, and is made of plastic. An object-side surface thereof, which faces the object side, is a convex aspheric surface, and an image-side surface thereof, which faces the image side, is a concave aspheric surface. The object-side surface 622 and the image-side surface 624 both has an inflection point thereon.

The third lens 630 has positive refractive power, and is made of plastic. An object-side surface 632, which faces the object side, is a convex aspheric surface, and an image-side surface 634, which faces the image side, is a convex aspheric surface. The object-side surface 632 has an inflection point thereon.

The fourth lens 640 has negative refractive power, and is made of plastic. An object-side surface 642, which faces the object side, is a concave aspheric surface, and an image-side surface 644, which faces the image side, is a convex aspheric surface. The object-side surface 642 has an inflection point thereon.

The fifth lens 650 has negative refractive power, and is made of plastic. An object-side surface 652, which faces the object side, is a concave aspheric surface, and an image-side surface 654, which faces the image side, thereof is a concave aspheric surface. The image-side surface 654 has an inflection point thereon.

The infrared rays filter 670 is made of glass, and between the fifth lens 650 and the image plane 680. The infrared rays filter 670 gives no contribution to the focal length of the system.

The optical image capturing system of the sixth preferred embodiment has the following parameters, which are  $|f2|+|f3|+|f4|=201.6178$  mm;  $|f1|+|f5|=8.4371$  mm; and  $|f2|+|f3|+|f4|>|f1|+|f5|$ , where  $f1$  is a focal length of the first lens 610;  $f2$  is a focal length of the second lens 620;  $f3$  is a focal length of the third lens 630;  $f4$  is a focal length of the fourth lens 640; and  $f5$  is a focal length of the fifth lens 650.

The optical image capturing system of the sixth preferred embodiment further satisfies  $TP4=0.7356$  mm and  $TP5=0.3985$  mm, where  $TP4$  is a thickness of the fourth lens on the optical axis, and  $TP5$  is a thickness of the fifth lens on the optical axis.

In the sixth embodiment, the first and the third lenses 610, 630 are positive lenses, and their focal lengths are  $f1$  and  $f3$  respectively. The optical image capturing system of the sixth preferred embodiment further satisfies  $\Sigma PP=f1+f3=8.0203$  mm and  $f1/(f1+f3)=0.7983$ , where  $\Sigma PP$  is a sum of the focal lengths of each positive lens. It is helpful to share the positive refractive power of the first lens 610 to the other positive lens to avoid the significant aberration caused by the incident rays.

The optical image capturing system of the sixth preferred embodiment further satisfies  $\Sigma NP=f2+f4+f5=-202.0346$  mm and  $f5/(f2+f4+f5)=0.4950$ , where  $f2$ ,  $f4$  and  $f5$  are focal lengths of the second, the fourth and the fifth lenses, and  $\Sigma NP$  is a sum of the focal lengths of each negative lens. It is helpful to share the negative refractive power of the fifth lens 650 to other negative lenses to avoid the significant aberration caused by the incident rays.

The parameters of the lenses of the sixth embodiment are listed in Table 11 and Table 12.

TABLE 11

f = 2.97861 mm; f/HEP = 1.4; HAF = 50.0001 deg; tan(HAF) = 1.1918							
Surface		Radius of curvature (mm)	Thickness (mm)	Material	Refractive index	Abbe number	Focal length (mm)
0	Object	plane	infinity				
1	1 <sup>st</sup> lens	2.3988	0.456243	plastic	1.565	58	6.40246
2		6.5902	0.08838				
3	Aperture	plane	0.411254				
4	2 <sup>nd</sup> lens	144.6516	0.349143	plastic	1.565	58	-100
5		40.68654	0.084996				
6	3 <sup>rd</sup> lens	24.44361	0.808138	plastic	1.583	30.2	1.61783
7		-0.97508	0.05				
8	4 <sup>th</sup> lens	-0.85898	0.735623	plastic	1.565	58	-100
9		-1.1424	0.685879				
10	5 <sup>th</sup> lens	-4.05486	0.39853	plastic	1.65	21.4	-2.0346
11		2.06441	0.3				
12	Filter	plane	0.2		1.517	64.2	
13		plane	0.203492				
14	Image plane	plane	0.160725				

Reference wavelength: 555 nm. The clear aperture of the first surface is 1.22 mm; the clear aperture of the sixth surface is 1.03 mm.

TABLE 12

Coefficients of the aspheric surfaces						
	Surface					
	1	2	4	5	6	7
k =	-21.439717	-1.976571	50	7.326364	47.916247	-2.428818
A4 =	1.48662E-01	8.76887E-03	-1.52157E-01	-2.00834E-01	-2.41634E-01	-2.12630E-02
A6 =	-7.96597E-02	6.85471E-02	2.42208E-01	2.68748E-02	2.13077E-01	6.92905E-02
A8 =	-1.58109E-02	-2.96673E-01	-4.66625E-01	3.06661E-02	-4.51221E-01	-4.92997E-02
A10 =	7.81152E-02	5.44324E-01	2.82724E-01	-2.44715E-01	3.10208E-01	-2.32974E-02
A12 =	-4.98017E-02	-4.52039E-01	5.24873E-02	2.50479E-01	-3.36706E-02	3.25165E-02
A14 =	1.00061E-02	1.38629E-01	-1.42016E-01	-9.17983E-02	-2.81886E-02	-1.01056E-02

	Surface			
	8	9	10	11
k	-1.394704	-3.03247	-39.215327	-17.127864
A4	2.18458E-01	-1.62687E-02	-1.21846E-01	-2.08246E-02
A6	-1.66227E-02	-9.55726E-03	5.40811E-02	-1.91521E-04
A8	-3.17545E-02	1.15509E-02	-3.24253E-02	1.61481E-04
A10	1.19463E-04	-9.11869E-03	2.40979E-03	-2.19374E-06
A12	9.03458E-03	4.52160E-03	3.49318E-03	-1.72409E-06
A14	-2.85089E-03	-8.94094E-04	-8.19111E-04	8.06517E-08

An equation of the aspheric surfaces of the sixth embodiment is the same as that of the first embodiment, and the definitions are the same as well.

The exact parameters of the sixth embodiment based on Table 11 and Table 12 are listed in the following table:

TDT	1.4440%	InRS51	-0.5252
ODT	2.0614%	InRS52	-0.9300
ΣPP	8.0203	InRS51 /TP5	-1.1956
ΣNP	-202.0346	InRS52 /TP5	-0.4795
f1/ΣPP	0.7983	HIF511	1.9937
f6/ΣNP	0.4950	HIF521	0.7996
IN12/f	0.1677	HIF522	3.0991
HOS/f	1.6559	HIF523	0
HOS	4.9324	HIF311	1.4260
InTL	4.0682	HIF312	0

-continued

HOS/HOI	1.3188	HIF321	0.3813
InS/HOS	0.8896	HIF322	0.2891
InTL/HOS	0.8248	f/f1	0.4652
ΣTP/InTL	0.6754	f/f2	0.0298
(TP1 + IN12)/TP2	2.7378	f/f3	1.8411
(TP5 + IN45)/TP4	1.4741	f/f4	0.0298
(TP2 + TP3 + TP4)/ΣTP	0.6889	f/f5	1.4640

The exact parameters related to inflection points of the second embodiment (with main reference wavelength as 555 nm) based on Table 11 and Table 12 are listed in the following table:

HIF211	0.06201	HIF211/HOI	0.01658	SGI211	0.00001	$ SGI211 /( SGI211  + TP2)$	0.00002
HIF221	0.10119	HIF221/HOI	0.02706	SGI221	0.00010	$ SGI221 /( SGI221  + TP2)$	0.00023
HIF311	0.12076	HIF311/HOI	0.03229	SGI311	0.00025	$ SGI311 /( SGI311  + TP3)$	0.00054
HIF411	0.63436	HIF411/HOI	0.16961	SGI411	-0.18934	$ SGI411 /( SGI411  + TP4)$	0.29328
HIF412	1.15844	HIF412/HOI	0.30974	SGI412	-0.39491	$ SGI412 /( SGI412  + TP4)$	0.46397
HIF521	0.66495	HIF521/HOI	0.17779	SGI521	0.07720	$ SGI521 /( SGI521  + TP5)$	0.14472

It must be pointed out that the embodiments described above are only some preferred embodiments of the present invention. All equivalent structures which employ the concepts disclosed in this specification and the appended claims should fall within the scope of the present invention.

What is claimed is:

1. An optical image capturing system, in order along an optical axis from an object side to an image side, comprising:

- a first lens having positive refractive power;
- a second lens having refractive power;
- a third lens having refractive power;
- a fourth lens having negative refractive power;
- a fifth lens having refractive power; and
- an image plane;

wherein the optical image capturing system consists of the five lenses with refractive power; at least two of the five lenses each has at least an inflection point on at least a surface thereof; at least one of the lenses from the second lens to the fifth lens has positive refractive power; the fifth lens has an object-side surface, which faces the object side, and an image-side surface, which faces the image side, and both the object-side surface and the image-side surface of the fifth lens are aspheric surfaces;

wherein the optical image capturing system satisfies:

$$1.2 \leq f/HEP \leq 3.0; \text{ and}$$

$$0.5 \leq HOS/f \leq 3.0;$$

where f is a focal length of the optical image capturing system; HEP is an entrance pupil diameter of the optical image capturing system; and HOS is a distance in parallel with the optical axis from an object-side surface of the first lens to the image plane;

wherein the second lens has negative refractive power, and the fifth lens has negative refractive power.

2. The optical image capturing system of claim 1, wherein the optical image capturing system further satisfies:

$$0 \text{ deg} < HAF \leq 70 \text{ deg};$$

$$|TDT| < 60\%; \text{ and}$$

$$|ODT| < 50\%;$$

where HAF is a half of a view angle of the optical image capturing system; TDT is a TV distortion; and ODT is an optical distortion.

3. The optical image capturing system of claim 1, wherein the fifth lens has at least an inflection point on at least one of the surfaces thereof.

4. The optical image capturing system of claim 1, wherein the optical image capturing system further satisfies:

$$0 \text{ mm} < HIF \leq 5 \text{ mm};$$

where HIF is a distance perpendicular to the optical axis between any inflection point and the optical axis.

5. The optical image capturing system of claim 4, wherein the optical image capturing system further satisfies:

$$0 < HIF/InTL \leq 5;$$

where InTL is a distance in parallel with the optical axis between the object-side surface of the first lens and the image-side surface of the fifth lens.

6. The optical image capturing system of claim 5, further comprising an aperture and an image sensor on the image plane, wherein the optical image capturing system further satisfies:

$$0.5 \leq InS/HOS \leq 1.1; \text{ and}$$

$$0 < HIF/HOI \leq 0.9;$$

where InS is a distance in parallel with the optical axis between the aperture and the image plane; and HOI is a height for an image formation of the optical image capturing system.

7. The optical image capturing system of claim 4, wherein the optical image capturing system further satisfies:

$$0 \text{ mm} < SGI \leq 1 \text{ mm};$$

where SGI is a displacement in parallel with the optical axis from a point on a surface of the lens, through which the optical axis passes, to the inflection point on the surface.

8. The optical image capturing system of claim 1, wherein the optical image capturing system further satisfies:

$$0.6 \leq InTL/HOS \leq 0.9;$$

where InTL is a distance in parallel with the optical axis between the object-side surface of the first lens and the image-side surface of the fifth lens.

9. An optical image capturing system, in order along an optical axis from an object side to an image side, comprising:

- a first lens having positive refractive power;
- a second lens having refractive power;
- a third lens having refractive power;
- a fourth lens having negative refractive power;
- a fifth lens having negative refractive power; and
- an image plane;

wherein the optical image capturing system consists of the five lenses with refractive power; at least two of the five lenses each has at least an inflection point on at least a surface thereof; at least one of the lenses from the second lens to the fourth lens has positive refractive power; the fifth lens has an object-side surface, which faces the object side, and an image-side surface, which faces the image side, and both the object-side surface and the image-side surface of the fifth lens are aspheric surfaces;

wherein the optical image capturing system satisfies:

$$1.2 \leq f/HEP \leq 3.0;$$

$$0.5 \leq HOS/f \leq 3.0;$$

$$0.4 \leq |\tan(HAF)| \leq 3.0;$$

$|TDT| < 60\%$ ; and

$|ODT| \leq 50\%$ ;

where  $f_1$ ,  $f_2$ ,  $f_3$ ,  $f_4$ , and  $f_5$  are focal lengths of the first lens to the fifth lens, respectively;  $f$  is a focal length of the optical image capturing system; HEP is an entrance pupil diameter of the optical image capturing system; HOS is a distance in parallel with the optical axis between an object-side surface, which face the object side, of the first lens and the image plane; HAF is a half of a view angle of the optical image capturing system; TDT is a TV distortion; and ODT is an optical distortion;

wherein the optical image capturing system further satisfies:

$$0 < SGI521 / (TP5 + SGI521) \leq 0.8,$$

where SGI521 is a displacement in parallel with the optical axis from a point on the image-side surface of the fifth lens, through which the optical axis passes, to the inflection point, which is the closest to the optical axis, on the image-side surface of the fifth lens; and TP5 is a thickness of the fifth lens on the optical axis.

**10.** The optical image capturing system of claim 9, wherein at least one of the surfaces of the fourth lens has at least an inflection point thereon.

**11.** The optical image capturing system of claim 9, wherein at least one of the surfaces of the fifth lens has at least one inflection point thereon.

**12.** The optical image capturing system of claim 9, wherein the optical image capturing system further satisfies:

$$0 \text{ mm} < HOS \leq 7 \text{ mm}.$$

**13.** The optical image capturing system of claim 9, wherein the optical image capturing system further satisfies:

$$0 \text{ mm} < InTL \leq 6 \text{ mm};$$

where InTL is a distance in parallel with the optical axis between the object-side surface of the first lens and the image-side surface of the fifth lens.

**14.** The optical image capturing system of claim 9, wherein the optical image capturing system further satisfies:

$$0 \text{ mm} < \Sigma TP \leq 5 \text{ mm};$$

where  $\Sigma TP$  is a sum of central thicknesses of the lenses, which have refractive power, on the optical axis.

**15.** The optical image capturing system of claim 9, wherein the optical image capturing system further satisfies:

$$0 < IN12 / f \leq 0.2;$$

where IN12 is a distance on the optical axis between the first lens and the second lens.

**16.** The optical image capturing system of claim 9, wherein the optical image capturing system further satisfies:

$$0.01 \leq f_1 / (f_1 + f_3) \leq 0.9.$$

**17.** The optical image capturing system of claim 9, wherein the optical image capturing system further satisfies:

$$0 < |f/f_1| \leq 2;$$

$$0 < |f/f_2| \leq 2;$$

$$0 < |f/f_3| \leq 3;$$

$$0 < |f/f_4| \leq 3; \text{ and}$$

$$0 < |f/f_5| \leq 3.$$

**18.** An optical image capturing system, in order along an optical axis from an object side to an image side, comprising:

- a first lens having positive refractive power;
- a second lens having refractive power;
- a third lens having refractive power;
- a fourth lens having negative refractive power;
- a fifth lens having negative refractive power, and having at least an inflection point on an image-side surface, which faces the image side, and an object-side surface, which faces the object side, respectively, wherein at least one surface between the image-side surface and the object-side surface thereof has at least an inflection point; and

an image plane;

wherein the optical image capturing system consists of the five lenses having refractive power; the object-side surface and the image-side surface of the fifth lens are aspheric surfaces; at least one lens between the third lens and the fourth lens has at least one inflection point on at least one of the surfaces thereof;

wherein the optical image capturing system satisfies:

$$1.2 \leq f / HEP \leq 2.8;$$

$$0.4 \leq |\tan(HAF)| \leq 3.0;$$

$$0.5 \leq HOS / f \leq 3.0;$$

$|TDT| < 60\%$ ; and

$|ODT| \leq 50\%$ ;

where  $f_1$ ,  $f_2$ ,  $f_3$ ,  $f_4$ , and  $f_5$  are focal lengths of the first lens to the fifth lens, respectively;  $f$  is a focal length of the optical image capturing system; HEP is an entrance pupil diameter of the optical image capturing system; HAF is a half of a view angle of the optical image capturing system; HOS is a distance in parallel with the optical axis between an object-side surface, which face the object side, of the first lens and the image plane; TDT is a TV distortion; and ODT is an optical distortion;

wherein the fifth lens has at least an inflection point on each surface thereof; and the optical image capturing system further satisfies:

$$0.01 \leq f_1 / (f_1 + f_3) \leq 0.9; \text{ and}$$

$$0.01 \leq f_5 / (f_2 + f_4 + f_5) \leq 0.95.$$

**19.** The optical image capturing system of claim 18, wherein each of the inflection points in the optical image capturing system further satisfies:

$$0 \text{ mm} < HIF \leq 5 \text{ mm};$$

where HIF is a distance perpendicular to the optical axis between said inflection point and the optical axis.

**20.** The optical image capturing system of claim 18, wherein the optical image capturing system further satisfies:

$$0.6 \leq InTL / HOS \leq 0.9;$$

where InTL is a distance in parallel with the optical axis between the object-side surface of the first lens and the image-side surface of the fifth lens.

**21.** The optical image capturing system of claim 18, wherein the optical image capturing system further satisfies:

$$0.45 < \Sigma TP / InTL \leq 0.95;$$

where  $\Sigma TP$  is a sum of central thicknesses of the lenses, which have refractive power, on the optical axis; and

InTL is a distance between the object-side surface of the first lens and the image-side surface of the fifth lens.

**22.** The optical image capturing system of claim **18**, further comprising an aperture and an image sensor on the image plane, wherein the optical image capturing system 5 further satisfies:

$$0.5 \leq \text{InS}/\text{HOS} \leq 1.1;$$

where InS is a distance in parallel with the optical axis between the aperture and the image plane. 10

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